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WATERLOGGING AND SALINITY MANAGEMENT IN THE SINDH PROVINCE, PAKISTAN

Volume Two

THE FARMING SYSTEM: POTENTIAL FOR INVESTMENT AND RETURNS IN SINDH, PAKISTAN

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THE FARMING SYSTEM: POTENTIAL FOR INVESTMENT AND RETURNS IN SINDH, PAKISTAN

I INTRODUCTION

A. Importance

The avoidance of risk in farming and sustainability in productivity are largely insured through managing irrigation properly. Water is a precious input in farming because the potential of genetic improvement in the crop varieties and agronomic innovations can be fully tapped only if the irrigation is made available in the vast areas where the annual precipitation is very low/inadequate. Irrigation provides the scope for sustainable agriculture and paves the way for alleviating rural poverty, hunger and malnutrition. Irrigation water is essential to Pakistani farmers because it means an assured crop, higher yields, more income and more employment. To Pakistan, it means 24.5 percent of the gross domestic product, 26 percent of public revenues and 64 percent of all exports provided by products originating in the agricultural sector (GOP, 1997-98). If irrigation is managed properly, increasing the intensive and extensive use of land becomes possible in three ways: (1) It helps to bring new lands (that are otherwise fallow/barren) under cultivation, and thereby, increases the net sown area on the farms; (2) It makes possible to grow more area under crops in the dry seasons and thereby increases the land use intensity; and (3) It enables growing shorter duration crops (which cannot be grown without an adequate and dependable water supply), and thereby, makes multiple cropping possible (Jehangir and Sampath, 1991).

The role and importance of irrigation resources and their management in the context of the country's increasing population can hardly be exaggerated. The population of Pakistan was reported to have been 132 million in 1996 (GOP, 1995-96) and is projected to be 207 million in 2013 (WSIP, 1990). Given this widespread growth in human numbers in the history of Pakistan, a required magnitude of food production for the projected population has been determined and is given in Table-1. Corresponding irrigation requirements for the years 2000 and 2013 would be 176 and 254 Billion Cubic Meters (BCM), respectively (Table-2). These requirements do not include urban and industrial water uses. When allowing for these non-irrigation uses, the estimated overall water requirements would be 183 and 265 BCM for the years 2000 and 2013, respectively. The examination of Table-1 and Table-2 would reveal a very anguished scenario. On one hand, corresponding to the required 28.4 million tons (MT), the estimated food grains production would be 22 MT by the year 2000 (i.e. about 23 percent shortage of food grains by the year 2000). This deficit in grain production will almost double, i.e. 12 million tons in the year 2013 (Table-1). On the other hand, the water availability falls short of requirements by 50 and 133 BCM in the years 2000 and 2013, respectively (Table 2). Consequently, the agricultural production would fail to meet the demand (Table 1).

Table 1. Agricultural Requirements and Potential Production.

(Million Tons)

Year	2000			2013		
Population	148 Million			207 Million		
Crops	**Requirement**	**Production**	**Shortfall**	**Requirement**	**Production**	**Shortfall**
Food Grains	28.4	22.0	6.4	39.0	27.0	12.0
Sugarcane	47.2	37.9	9.3	66.0	42.3	23.7
Cotton(Lint)	2.0	1.7	0.3	2.9	2.2	0.8
Pulses	1.1	0.8	0.2	1.4	1.1	0.3
Oilseed (Ex.Cotton)	1.9	0.7	1.2	2.8	1.1	1.7
Vegetables	8.2	5.6	2.6	10.5	7.4	3.1
Fruit	9.2	5.5	3.5	14.3	7.3	7.0
Total	98	74.2	23.5	136.9	88.4	48.6

Source : Planning Commission and WSIP, 1990.

Given the high economic value of irrigation water and its scarcity in relation to demand, the importance of using it most efficiently and productively is obvious, but the current irrigation practices in the Indus Basin can hardly meet the criteria of good water management. The economic potential of the agricultural land use in the country is determined by how efficiently the land in that country has been utilized; irrigated or unirrigated. These lands differ in productivity due to its land use intensity based on agro-climatic conditions, the presence of public/private irrigation facilities, the location, or due to the presence of other factors like salinity or waterlogging.

Table 2. Water Requirement and Availability in Year 2000 – 2025.

(BCM)

Year	**2000**	**2013**	**2025**
Population (Million)	148	207	267
Water Requirement			
Irrigation	177	255	
Non-Irrigation	7	11	
Total	184	265	342
Water Availability			
Total Surface & Ground	134	132	156
Shortfall	50	133	186

Source: Malik, 1995.

The ownership status also plays an important role when explaining the productivity differences. Productivity differences have been observed in many under-developed countries. The prevailing literature on rural development is filled with inquiries about the effect of the farm size and land productivity. In one respect, the debate is important as it provides information about the presence of economies/diseconomies of scale in agriculture, and about the selection of the optimal farm size.

The debate on the productivity differences in India was first started by Sen (1962), beginning with his analysis of India's Farm Management Studies of the mid-1950's. Then, differences in productivities by farm size were brought up by a number of farm management studies carried out in India, Pakistan and other developing countries during the 1960's and 1970's. The most frequently stated proposition was that an inverse relationship between output per acre and farm size exists. These studies tried to explain the apparent low land productivity on large farms by testing the hypothesis that large farms make a smaller use of variable inputs per acre. The lack of proper management and the inefficient use of land resources were quoted to be major reasons for low productivity on large farms in developing countries. [Sen (1962), Chennareddy (1962), Sen (1964), Hopper (1965), Sen (1966), Rao (1967), Saini (1969), Cline (1970), Bhattacharya and Saini (1972), Dey and Rudra (1973), Bharadwaj (1974), Khusro (1974), Berry and Cline (1979)].

B. History of Irrigated Agriculture in Sindh

Agriculture in the Sindh Province has been practiced around the Indus River since time immemorial. However, the planned irrigation system came into being after the commissioning of the Sukkur Barrage. Now, the three barrages (namely, Sukkur, Kotri and Guddu) mainly command about 5.78 Mha of the culturable command area in the Sindh Province. Besides these barrages, the agriculture in the Sindh Province is dependent upon 14 feeder and main canals and 1,462 branch canals, distributaries and minors having a total length of 19,780 km (SID, 1997).

The Sukkur Barrage commissioned in 1932, provides irrigation to about 3.106 Mha through its seven canals; three on the Right Bank of the Indus River namely, North Western, Rice and Dadu Canals and four on the Left Bank, namely, Nara, Rohri, Khairpur East and Khairpur West Canals. The Kotri Barrage was commissioned in 1955, provides irrigation to about 1.161 Mha of culturable command area through the Fuleli, Pinyari and Akram Wah Canals on the Left Bank and connects to the Kalri Lake through the Kalri Bhagar Feeder for providing drinking water to the city of Karachi. The Guddu Barrage commissioned in 1962, and provides irrigation to about 0.866 Mha of culturable command area through three canals on the right bank, i.e. the Desert, the Pat Feeder and Begari Canal, as well as the Ghotki Feeder on the Left Bank of the Indus River. The Pat Feeder also carries the share of the Pat Feeder Canal in the Baluchistan Province.

The current study takes into account the data collected from about 14 canal commands namely, the Begari, Dadu, Desert, Fuleli, Ghotki, Jamrao, Khairpur East, Khairpur West, Lined Channel, Nara, North West, Pinyari, Rice and Rohri Canals.

1) Problem of Waterlogging, Salinity and Drainage in Sindh

Another current physical constraint that is a major threat to the irrigated farm economies in Pakistan is the increase of area under waterlogging and salinity. The problem of waterlogging was the result of the seepage from the irrigation canals. In order to arrest this problem, the Government of Pakistan launched different Salinity Control and Reclamation Projects (SCARPs) starting in 1959. During the late 1980s, the studies revealed the occurrence of secondary salinization and its increasing trend towards the tail reaches of the supply system [Chaudhry et.al (1978), Johnson et al, (1977), Clayma and Ashraf (1975) Lowdermilk et. al (1978), Bhatti (1990)]. The barrage-controlled irrigation in the Sindh Province resulted in the assured and more timely supplies for the existent cultivated areas, the development of new areas, and in some commands, the provision of water in winter. Since, at the start of these irrigation systems, consideration was not given to the problem of drainage, the major adverse effect of the barrage-controlled system in the absence of drainage has been the rise in the watertable and a consequential increase in the soil salinity. About 0.69 Mha of the irrigated area was reported to have the problem of waterlogging and salinity during 1960 (GOP 1964). As a result, the production of crops have been seriously affected in the areas severely affected by waterlogging and salinity, and cultivated lands have been progressively abandoned. Out of the total culturable waste areas in the Sindh Province, about (0.45, 0.51 and 0.57 Mha in 1972, 1980 and 1990, respectively) 0.23 and 0.31 Mha were affected by the problem of waterlogging and salinity during 1980 and 1990, respectively.

Recent research studies on the subject has cautioned that soil conservation and the efficient utilization of available cultivable land is the only realistic answer to increase the crop productivity in order to feed the ever-growing population of developing countries. These studies further signify that the customary ways of expanding the available land from unirrigated to irrigated lands by constructing dams, reservoirs, and canals can no longer provide a satisfactory solution to irrigated agriculture. The argument was that the green revolution period (1970's) focused agricultural development policies in developing countries on modernizing the agriculture through different subsidy programs, which provided cheaper inputs to the farmers of these countries. The criticism for such strategies is that the benefits of those policies were reaped by the large farmers of these developing countries and not by the small farmers, because poor farmers could not access modern inputs due to resource constraints [Bagi (1981), Doelalikar (1981), Cornia (1985), Feder (1985), Khan and Akbari (1986), Afzal (1989), Mann (1989), Taslim (1990), Hallam (1991), Latif et al (1993) Yaseen and Rao (1993)].

The current study has been conducted to identify the geographical distribution of the current resource base in the Sindh Province. The study analyzes the on-farm data with respect to the estimation of the unused cultivable lands, estimation of the relationship of the output with respect to the agricultural inputs, tenure, farm size, and irrigation and land use intensity. This study intends to determine the efficiency of resource use on farms located in 14 canal commands of Sindh. It also intends to estimate the operational distribution of land holdings in Sindh across different farm-size groups and their relationship with unused cultivable lands. An understanding of these relationships will enable better identification of farm-size, interregional, and inter-temporal shifts in the sign and size of different parameters.

C. Objectives

The specific objectives of the study are to:

- Document the temporal changes in the farm size, land use, tenure, input-use pattern and the resulting production of the major crops in the Sindh Province;
- Examine the spatial differences in the key inputs and returns from the major crops at the canal command level in the Sindh Province, and farmers' perceptions about the major physical and economic constraints affecting the irrigated agriculture in the Sindh Province;
- Study the relationship between the size of the holding and the level of unused cultivable land, and the effect of the level of irrigation on the culturable waste areas;
- Estimate the relationship between cropping intensity and the size of the holding, and the influence of the level of irrigation on the cropping intensity;
- Estimate the efficiency of the land use across the canal command level with respect to the farm size in the irrigated areas of the Sindh Province;
- Identify the production potential of major crops for different farm categories in each of the canal commands in the Sindh Province; and
- Engage the applied use of a dynamic model to collectively account for the viability of interventions specified by the production function

D. Organization of the Study

The study is organized into six sections. Section 2 describes the sampling methodology, data source, levels of data aggregation, characteristics of census data variables, and econometric criteria being used in the present study. The historical perspective of temporal changes in the production of major crops and the changes in the level of input use are described in Section 3. The Section 4 describes the current production practices and the farmers' perceptions about the constraints to the agricultural production in Sindh. Section 5 estimates the uncultivable waste lands in Sindh at the canal command level and studies the relationship between farm size and unused lands. Also, it estimates the level of efficiency of the land use across the farm size by using the primary data collected from the field and the secondary district level data. Section 6 highlights the cost and returns from the major crops in Sindh during 1997-98. The summary and conclusion are given in Section 7.

II SAMPLING METHODOLOGY AND DATA SOURCE

A. Data Collection

Primary and secondary data sets have been used to carry out the present study. The primary data sets comprised the survey data of 1,539 sample farms located at 795 sample sites across 14 canal commands of the lower Indus Basin in the Sindh Province. The secondary data comprised 40 years data from the Agricultural Census reports (1960-1990), Agricultural Statistics of Pakistan (1997-98), and Economic Survey of Pakistan (1998). The descriptions of the data variables and the processing of the agro-economic data are given in the following section.

1) Primary Data Collection and IIMI Sample Coverage

Sample areas were identified for IIMI-specific data collection through the use of high resolution satellite images. Subsequently, these were fed into sequential processing by a calibrated groundwater salinity model and a host of economic models. The remote sensed images of the Sindh Province and the GIS modeling played a key role in the selection of the sampling sites (as described in Vol. I. of the report).

i) Pre-testing Questionnaire and Training Enumerators

Before the actual data collection, the questionnaire was pre-tested in the field in order to evaluate its workability, and as a result, appropriate modifications were made. The revised questionnaire was pre-tested once more in another location among the non-sampled villages of the Left and the Right Banks of the Indus River. Rigorous training has been imparted to the enumerators over several sessions. The purpose of imparting training was to avoid conceptual biases in data collection. The first session served as an explanatory session, in which the procedure for selecting respondents was explained. The following session focused on commonly made mistakes when obtaining information using a structured questionnaire. Another session highlighted the concepts used in the questionnaire, background objectives, and the meanings of various questions.

Subsequently, respondents were asked to interview the trainer, so that their mistakes were immediately indicated for ratification. This exercise was repeated numerous times to ensure that the enumerators and trainers were in full understanding. The final session entailed coding procedures, in which the importance of using accurate codes was also discussed in detail. After these sessions, the enumerators were taken to the field, and trainers conducted two demonstration interviews. Later, each enumerator was asked to conduct one interview in the presence of the trainer. The enumerators' completed questionnaires were examined in another session, and mistakes made in data collection were discussed at length. Enumerators were also asked, and encouraged, to note responses considered deviations from coded responses. These were added to the coding list, and modified accordingly for distribution among enumerators. The actual data collection started during December 1997 and continued until the end of June 1998.

2) Farm Level Stratification

The sample areas comprise 14 canal commands, which provide irrigation supplies to farms located in 15 districts (Sukkur, Larkana, Nawabshah, Mirpurkhas, Sanghar, Shikarpur, Thar, Thatta, Umerkot, Naushehro Feroze, Khairpur, Jaccobabad, Hyderabad, Ghotki and Dadu District, as listed in Table 3). The primary data were collected from 1,539 farms located in 795 different sampling sites defined through GIS modeling, as shown in Figure 1. Out of the total number of 1,539 farms, 554 farms were located on the Right Bank of the Indus River (166 farms were located in canal command areas of the Begari, 31 in the Dadu, 61 in the Desert, 193 in the Northwest and 103 farms in the Rice Canals). About 985 farms were located on the Left Bank of the Indus River). The distribution of the sample site shows that about 74 sample farms were selected randomly from the Fuleli Canal command area, 186 on the Ghotki Canal, 128 on the Jamrao Canal, 79 on the Khairpur East Canal, 65 on the Khairpur West Canal, 56 on the Lined Channel, 104 on the Nara Canal, 25 on the Pinyari Canal and 267 farms on the Rohri Canal command area.

3) Processing Farm Level Data

During the farm survey, farmers were asked to provide information about their farm sizes in acres; tenurial status (owner, owner-cum-tenant, tenant and lessee); land use pattern (Kharif 1997 and Rabi 1997-98); fallow area (area not cropped during each season); land rent; culturable waste area; incidence of soil salinity on the farm (in terms of Achoo / white Kallar); sodicity (Karo / black Kallar); waterlogging; cropping intensity; availability of irrigation supplies; input usage and costs; cultural and agronomic practices; yields of the major crops; prices received for the farm produce and farm pattern; irrigation sources; any significant changes in production during the last ten years (increasing/decreasing) and the reasons; ground water quality on the farm; reclamation measures, if adopted; and drainage conditions on the farm. Farmers' perceptions about the drainage problems on the farms were also gathered.

The farmers' responses were recorded on a well designed pre-tested questionnaire. The questionnaire provided the general information about the farms and the specific information about the input usage, for specific crops, and the output of these crops on each of the farms. These general responses were coded according to a well-designed coding scheme and were recorded in the spreadsheet. The crop-specific usage of inputs [(information about the number of ploughings by Gobal (Disc Harrow), Punjphara (Five tine cultivator), Ordinary Cultivator (11 tine cultivator) planking, seed rate, fertilizer type/quantity, irrigation type/applications, insecticide / weedicide, quantity / application, labor usage, cost of threshing/harvesting etc.)] and the output for each of the four crops (wheat, rice, cotton and sugarcane) were also recorded in the spreadsheets. To determine the total farm revenue, the farmers were also asked about the prices they received for the specific crop output and about the value of the by-products for all the four major crops.

4) Aggregate Sample Domain

As already mentioned, the total farm data at the Sindh level include the data of 1,539 farms. The data matrix has columns comprising the coded data information about the polygon number, sample number, name of the respondent, village/Goth name, district, land ownership, leasing-in or renting-out information, farm size, land use, soil classification, fallow area on the farm, reasons for keeping the land fallow, cultivated area, cropping pattern, area under crops, cropped area destroyed due to calamity, etc., source of irrigation, irrigation time, quality of irrigation water, depth of the tubewell, information about the changes in the depth to watertable, information about changes in the yield, incidence of drainage problems on the farms and the farmers' practices about managing the drainage problem. The sample of the master matrix is shown in Appendix A. The major results derived from this master matrix are discussed in the ensuing sections of the report.

B. District Level Census Data

The district-wise, temporal, farm-size-wise cross-section data used in this study are taken from the four Agricultural Census reports of Pakistan for 4 census years, i.e. 1960, 1972, 1980 and 1990. One main advantage of these data sets is that they not only cover the pre-Green Revolution/Pre-SCARP period (1960) and the initial Green Revolution/SCARP period (1972 & 1980), but also the matured Green Revolution/SCARP period (1990). Three levels of data integration have been incorporated, i.e. overall Sindh level, district level and canal command level data.

1) Data Integration

At the grand integration level, all the survey data sets pertaining to the entire canal command and (1,539) was integrated based on the GIS classification criteria. The Census data sets for all of the districts and all the census years for entire the Sindh level comprises 36 cases (nine farm categories for each district[1] for four census years). All the farms in each category across all of the districts were added to arrive at the total number of farms and area and other relevant variables for Sindh as a whole (i.e., Sindh average of nine farm categories for each census year * 4 census years = 36 cases). The first level of disintegration involved using the data for nine farm categories for the three census years (1960-72) in each of the 10 districts, twelve districts during the 1980 census year and thirteen districts during 1990. This produced a data set of 405 cases related to time-series and cross-sectional observations (i.e., an average of nine farm categories for each of the census years (1960-72) * ten districts * two census years (9*10*2 = 180), plus nine farm categories of twelve districts (9*12=108) for the 1980 census year and 13 districts for the 1990 census year (9*13=117), amounting to the total of 405 cases). The purpose of the exercise was to see the kind of inferences that could be drawn according to the level of integration used. Some light may be thrown on the pre-SCARP and post-SCARP, differences in the land use intensity and cropping intensity that are present in the levels of integration. Small farms, on an average, are expected to employ more labor, and larger farms are expected to employ less family labor and more hired labor, the hypotheses are stated for the average behavior for a particular farm-size group. If that is the case, then the best way to represent the relationship in the regression equation will be to define it in terms of averages for each group and use the averages in the estimation of the regression parameters (Rao and Miller, 1972).

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[1]The nine operational farm-size categories are:

1: < 0.05 ha	4: 2.0 – 3.0 ha	7: 10.0 - 20.0 ha
2: 0.5 -1.0 ha	5: 3.0 – 5.0 ha	8: 20.0 - 60.0 ha
3: 1.0 -2.0 ha	6: 5.0 – 10.0 ha	9: 60.0 and above.

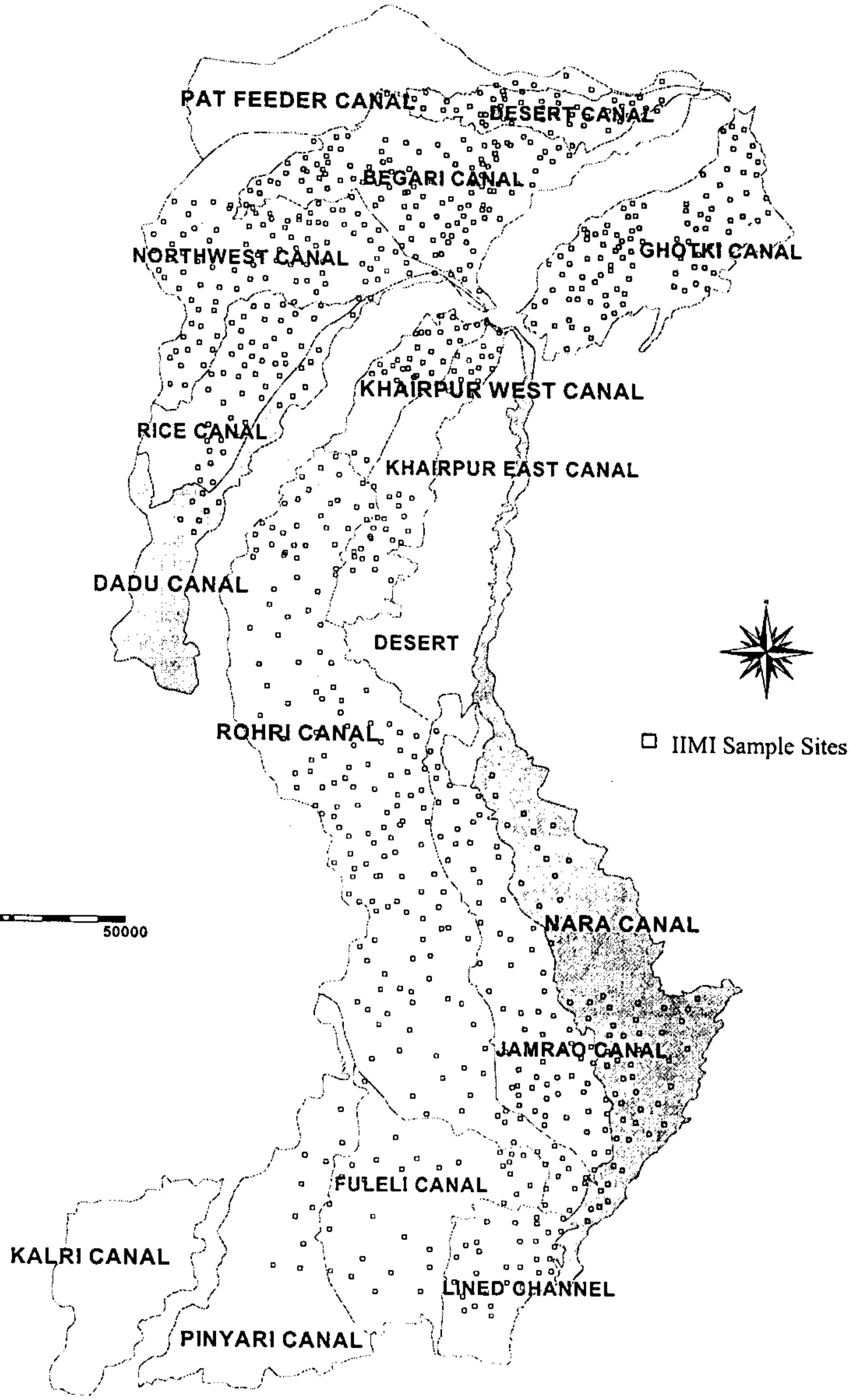

Figure 1. Location of IIMI-Sample Site across the Sindh Hydrological divides (1997).

C. Sample Population in Sindh

Table 3 shows that the sample population in the Sindh Province is distributed across fourteen canal commands comprising 1,539 farms and covering about 45,605 hectares of land. About 166 sample farms are located in the Begari Canal, which constitute 11 percent of the total sample population. The percentage distribution of the samples in all the canal commands is depicted in Table 3. The average area for these farms reveals that the farm size in the command areas of the Nara, Rohri, Jamrao, Begari and Desert Canals is more than other canals, which vary form 35 to 51 hectares. In the Dadu, Khairpur West and Khairpur East Canals, the average farm size varies from 4 hectares to 6 hectares. Farms in the Khairpur East and West Canals are more fragmented than in the Rohri, Nara and Jamrao Canals. Farm sizes have a significant effect on land use intensity and cropping intensity; in large farms a part of the farm area remains unused as waste or fallow land. But in small farms, cultivators try to use land intensively. Small farmers do not leave the farm area unused. For analytical purposes, the sample farms are divided into three farm classes i.e., Small, Medium, and Large. Farm managers manage most of these farms, and tenants cultivate land. Owners of these farms remain absent and interfere little in farm operations. According to the Census of Agriculture, farms comprising less than 2 ha are classified as Small farms, 2 to 10 ha are classified as Medium farms and 10 - 60 ha of land are classified as Large farms. The extra-large farm category is defined for farmers who own more than 60 ha of land.

Table 3. Distribution of Sample Farms and Farm Area in Canal Commands of Sindh.

Canal Command	Number	% Farms across canal command	Area	% Area across canal commands	Average farm Size
Begari	166	11	7353	16.12	44
Dadu	31	2	112	0.24	4
Desert	61	4	2807	6.15	46
Fuleli	74	5	1559	3.42	21
Ghotki	186	12	3280	7.19	18
Jamrao	128	8	6583	14.43	51
Khairpur East	79	5	313	0.69	4
Khairpur West	67	4	381	0.83	6
Lined Channel	56	4	1234	2.71	22
Nara	105	7	6550	14.36	62
North West	191	12	4145	9.09	22
Pinyari	25	2	646	1.42	26
Rice Canal	103	7	1299	2.85	13
Rohri	267	17	9346	20.49	35
Sindh	**1539**	**100**	**45606**	**100**	**30**

Source: Sindh Waterlogging and Salinity Management Survey, 1997-98.

The description of the variables used in the current analysis is given in the ensuing section.

D. Description of the Variables

The present section deals with the measurement of variables used in the economic analysis of the study. Given the theoretical principles and availability of data, the variables are specified as described below:

1) Total Farm Crop Production

The total farm crop production is measured in value terms. The crop output will be defined as the sum of the monetary value of the total specific crop produced on the farm during the survey year of 1997-98. In this study, only the wheat, rice, sugarcane and the cotton crops (grown during Kharif 1997 and Rabi 1996-97) are for detailed investigation. Farmers were asked to give their best estimates about the production of the major crops on their farms. The gross return of each crop per farm consisted of the value of the crop output. To measure the total farm crop output in value terms, the price per 40 kg of crop output received by the farmers at the farm gate was used.

2) Amount of Labor

The farm labor performs different routine activities in crop production management. Farmers have been asked about the participation of the family's adults (male), women and children, as well as any hired labor contributions on the farm for different operations, as recorded in the questionnaire.

3) Irrigation Cost

The irrigation cost includes the tubewell cost (either diesel or electric) and charges for canal water. The prevailing market price of the tubewell water for one hour was taken as the opportunity cost of tubewell irrigation. To estimate the irrigation cost for a specific crop, the tubewell's per-hour operational cost was multiplied by the number of hours the tubewell was used for irrigating each of the major crops at the farm. The charges for the canal water and the amount paid for water hired from other people for each of the major crops, if any, were included in this expenditure. The manual labor required for irrigation was not included in the irrigation cost.

4) Fertilizer Cost

Fertilizer use has become the key component in crop production. The physical quantities of fertilizers containing nitrogen, phosphorus and potash for each of the major crops, and zinc for the rice crop, were taken into account. The farmers were asked about the type and quantity of fertilizer used for each of the major crops. The total fertilizer applied to each of the major crops on the farm was multiplied with their respective market prices to quantify this variable in value terms.

5) Dry Land Preparation

The farmers on the Left Bank of the Indus River were using the Gobal (Disc Harrow) for the first ploughing of the land, and then they used the ordinary cultivator. In contrast to the cotton and sugarcane crops, the roots of rice and wheat plants are superficial in nature and require a good preparation of the soil's top layer. Thus, the farmers on the Right Bank of the Indus River were found to customarily use the Punj Phara (Cultivator with five tines), and later they use the ordinary 11-tine cultivator for cultivating their rice fields. The number of dry ploughings and the number of plankings for dry land preparation used at each farm was used in the analysis.

6) Wet Land Preparation

In the Sindh Province, both on the Left and Right Banks of the Indus River, the farmers use the Kodar (wooden plank) in the wetland preparation for the rice crop. This requirement is to level the field for transplantation and to reduce the water percolation through the soil pores. It also reduces the germination of weeds and increases the soil's water retention capacity. Before the wet land preparation, the cultivated land is irrigated, and then the Kodar (wooden plank) is used to level the field in the puddle condition. The cost of the Kodar for wet land preparation per farm was added to the cost of the land preparation in the case of the rice crop.

7) Land

Expressed in hectares, land includes only the farm area used by the respondents to cultivate the major crops.

8) Average Culturable Waste Area per Farm (ACWA)

The culturable waste area is defined as "that uncultivated farm area that was fit for cultivation, but was not cropped during the survey year nor in the year before that; it also consists of saline/waterlogged patches of the land." In order to calculate the average culturable waste area per farm from the census reports, the total number of farms is divided by the total culturable waste area available in each farm category, i.e.:

$$ACAW = \frac{CWA}{FNO} \qquad (1)$$

Where:

ACWA = Average Culturable Waste Area per farm;
CWA = Total Culturable Waste Area on each farm category; and
FNO = Total Number of Farms in each farm category.

9) Average Farm Area Total per Farm (AFAT)

The total farm size represents the ownership size of the farm, which includes cultivated and uncultivated areas contained in the farm. In order to compute the average size of the land holding per farm, the total farm area in each farm category was divided by the total number of farms in each farm category, i.e:

$$AFAT = \frac{FAT}{FNO} \qquad (2)$$

Where:

AFAT = Average Farm Size in each farm category;
FAT = Total Farm Area on each farm category; and
FNO = As already defined.

10) Proportion of Irrigated to Total Cultivated Area per Farm (CAI/CAT)

In order to compute the proportion of irrigated to the total cultivated area, the total irrigated cultivated area in each farm category was divided by the total cultivated area in each farm category, i.e:

$$\text{Proportion of irrigated to cultivated area} = \frac{CAI}{CAT} \qquad (3)$$

Where:

CAI/CAT = Proportion of Irrigated to Cultivated Area;
CAI = Total Irrigated Area on each farm category; and
CAT = Total Cultivated Area on each farm category.

11) Gross Cropped Area (GCA)

This is defined as the aggregate area under crops raised on a farm during one year, including the area under fruit crops. It measures the intensive use of the land.

12) Net Sown Area (NSA)

This is defined as the cultivated farm area which is actually cropped during one year, regardless of the number of crops raised, and includes the area under orchards for the same year.

13) Cropping Intensity (CI)

The cropping intensity indicates the extent to which the cultivated area is used for cropping, and is computed as follows:

$$CI = \frac{GCA}{CAT} \qquad (4)$$

Where:

CI = Cropping Intensity on each farm category;
GCA = Gross Cropped Area on each farm category (as already defined); and
NSA = Net Sown Area on each farm category (as already defined).

14) Index of Inefficiency in Cropping Intensity

Inefficiency in the cropping intensity is an easy concept, but difficult to operationalize. At the conceptual level, it is the difference between the number of times a cultivated area is cropped in a year and the number of times the area could have been potentially cropped, the latter being difficult to measure. This requires resorting to certain assumptions considered reasonable within the limitations of the available data. For measuring the inefficiency in the cropping intensity, irrigated areas are assumed to have a potential for two crops and unirrigated areas have a potential for at least one crop. As such, the minimum potential number of times a unit area of land is croppable is equal to twice the net-irrigated area added to the unirrigated area. The index of inefficiency can be defined as:

$$\text{Inefficiency Index} = \frac{NSA + CAI - GCA}{NSA + CAI} \qquad (5)$$

Where:

NSA = Net Sown Area in each farm category;
CAI = Cultivated Area Irrigated in each farm category; and
GCA = Gross Cropped Area in each farm category.

There is a possibility for a negative number in certain cases because the unirrigated area may be cropped more than once and/or the irrigated areas may be cropped more than two times a year, thereby making the GCA greater than the sum of the NSA and CAI.

15) Index of Inefficiency in Total Use of Land (IITLU)

Inefficiency in the total utilization of land rests on the concept of potential gross cropped area, which is defined as the sum of unused land, unirrigated cropped area and twice the net irrigated area. Subtracting the GCA from this resulting number, indicates the gross area lost due to the inefficiency in the cropping intensity and the non-utilization of certain cultivable land. Thus, the index for measuring the inefficiency in the total utilization of land is calculated as follows:

$$IITLU = \frac{NSA + CAI + CWA - GCA}{NSA + CAI + CWA} \qquad (6)$$

Where:

NSA = Net Sown Area in each farm category;
CAI = Cultivated Area Irrigated in each farm category;
CWA = Culturable Waste Area in each farm category; and
GCA = Gross Cropped Area in each farm category.

The next section deals with the specification of econometric models.

E. Specification of the Econometric Models

1) Trends in Cropping Intensity and Culturable Waste Area in the Sindh Province

There are two aspects to the problem of the under-utilization of lands as mentioned earlier, viz., the proportion of cultivable area actually cultivated and how intensively the cultivated area is cropped in a year. Assuming a multiplicative relationship and using the econometric criteria suggested by Fuss, McFadden and Mundlak (1978) Madala (1988) and Ramaramunathan (1992), the following log-linear models were found to be the best fit for testing the relationship between the farm size, proportion of irrigation and their effects after the green revolution/SCARP on culturable waste areas and the cropping intensity. The dependent and independent variables, which are included in the models, are defined in the following:

$$\ln CWA = \ln a + \ln D_{72} + \ln D_{80} + \ln D_{90} + B_1 \ln FAT + B_2 \ln FAT_{72} + B_3 \ln FAT_{80} + B_4 \ln FAT_{90} + e \quad (7)$$

$$\ln CWA = \ln a + \ln D_{72} + \ln D_{80} + \ln D_{90} + B_1 \ln FAT + B_2 \ln FAT_{72} + B_3 \ln FAT_{80} + B_4 \ln FAT_{90} + B_5 \ln (CAI/FAT) + B_6 \ln (CAI/FAT)_{72} + B_7 \ln (CAI/FAT)_{80} + B_8 \ln (CAI/FAT)_{90} + e. \quad (8)$$

$$\ln CI = \ln a + \ln D_{72} + \ln D_{80} + \ln D_{90} + B_1 \ln FAT + B_2 \ln FAT_{72} + B_3 \ln FAT_{80} + B_4 \ln FAT_{90} + e \quad (9)$$

$$\ln CI = \ln a + \ln D_{72} + \ln D_{80} + \ln D_{90} + B_1 \ln FAT + B_2 \ln FAT_{72} + B_3 \ln FAT_{80} + B_4 \ln FAT_{90} + B_5 \ln (CAI/FAT) + B_6 \ln (CAI/FAT)_{72} + B_7 \ln (CAI/FAT)_{80} + B_8 \ln (CAI/FAT)_{90} + e. \quad (10)$$

Where:

CWA	= Culturable Waste Area in each farm category;
CI	= Cropping Intensity in each farm category;
a	= Constant term;
$B_{1\text{-}8}$	= Estimated Coefficients;
$D_{72\text{-}90}$	= Intercept Dummies for year 1972, 1980 and 1990, respectively;
FAT	= Average size of holding per farm in each farm category;
FAT72	= 1972 dummy for average size of holding per farm on each farm category;
FAT_{80}	= 1980 dummy for average size of holding per farm on each farm category;
FAT_{90}	= 1990 dummy for average size of holding per farm on each farm category;
(CAI/FAT)	= Proportion of irrigated area per farm on each farm category;
$(CAI/FAT)_{72}$	= 1972 dummy for proportion of irrigated area per farm on each farm category;
$(CAI/FAT)_{80}$	= 1980 dummy for proportion of irrigated area per farm on each farm category;
$(CAI/FAT)_{90}$	= 1990 dummy for proportion of irrigated area per farm on each farm category;
e	= Random error term.

According to Equation 7, if the proportion of culturable wasteland increases with the size of the holding, the value of the beta coefficient (B_1) would be greater than one, which means that as the farm size increases the amount of culturable waste area (CWA) increased more than proportionately before the green revolution / SCARPS projects. In order to find how this relationship has been affected by the green revolution/SCARPS / Drainage projects, the slope coefficients are summed up to see whether this relationship is strengthened or weakened, depending upon the sum of (B_1+B_2, B_1+B_3, B_1+B_4,) (whether it is greater than or less than B_1, respectively). To see how the increase in the proportionate area under irrigation affects the CWA, Equation 8 is estimated. A negative relationship between the increase in the proportionate area under irrigation and the effect of irrigation on CWA was anticipated. The intercept term will capture the impact of the technological development. Again, a negative relationship between the technological development and the CWA was anticipated. The equations in Models 9 and 10 were estimated to study the relationship between the cropping intensity (CI) and other variables such as the farm size and the level of irrigation, before, during and after the green revolution/SCARP / Drainage projects. The results are reported in the ensuing section. A negative relationship between the farm size and the CI and a positive relationship between the proportionate area under irrigation and the CI was expected. Also anticipated, is that technological development would lead to an increase in the CI, and a positive sign for the intercept term was expected. The intercept dummies provided the information about the temporal changes in the impact of the technological development on the CWA and CI.

2) Econometric Production and Profit Function Modeling

Econometric modeling will provide the basis for estimating the efficiency of resource allocation in the Sindh Province at the canal command level. The input response will be analyzed through the econometric estimation of the production function. The use of the production function will provide information needed in determining or specifying the use of resources and the pattern of outputs, which maximize farm profits. This study analyzes the relationship between crop productivity/profitability as it relates to farm size, gross cropped area, cropping pattern, agronomic inputs (seed, fertilizer, manure, irrigation, etc), salinity, groundwater quality and cultural practices, along with spatial and temporal dummy variables.

3) Functional Form

Economic theory rarely provides precise mathematical forms of economic relationships. There is a wide variety of equations to choose from to represent any economic function. In studying agricultural relations, economists predominantly use the linear, quadratic, and Cobb-Douglas forms. At least four functional forms (linear, quadratic, semi-log, and log linear forms, and most probably some other appropriate functional forms along with dummy variables) will be applied and the results of the selected equations will be discussed. The widely accepted procedure is to choose the function that best explains the variation in the dependent variable. Equations having the highest R^2 and least residual sum of squares are used to select the best fit [Maddala (1988), Koutsiyiannis, (1977)]. This study will analyze the resource use efficiency based on the variables included in the model as defined below:

$$Y_{ij} = f(S_{ij}, L_{ij}, N_{ij}\ F_{ij}, I_{ij}, ,C_{ij}\ O_{ij}) \quad \textbf{(11)}$$

Where:

Y = Total revenue from the major crops Rs/ha;
S = Seed (Rs./ha);
L = Total cost of the land preparation per farm for major crops (Rs);
F = Expenses on organic and inorganic fertilizers (Rs./ha);
N = Amount of labor used for raising major crops per (man-days/ha);
C= Total cost of insecticide/herbicide applied to the major crops per farm (Rs);
I = Total cost of the irrigation (canal + tubewell) for major crops per farm (Rs./ ha) and;
O= Other expenses (Rs./ha).

The subscript (i = 1, 2 and 3) represents different soil type classifications, where 1 is for normal soils, and 2 and 3 are for moderately suitable soils and saline sodic soils, respectively. Another subscript (j = 1, 2, 3, & 4) indicates the 4 major crops, i.e. rice, wheat, sugarcane and cotton. The results of these models will be used in the dynamic modeling to determine the projected yield and the production in the Rohri Canal command area.

4) Econometric Criteria

Regarding the econometric criteria in selecting the best equation among the wide variety of compatible functional forms, Fuss, McFadden and Mundlak (1978) have suggested a list of criteria to select a functional form, which are described below:

a) Parsimony in Parameters

The functional form should contain only those parameters that are necessary for consistency with the maintained hypotheses. An excess of parameters escalate the problem of multicollinearity, which tends to be severe in many applications due to market substitution, which causes prices, and hence, the quantities, to be highly correlated.

b) Ease of Interpretation

Excessively complex or parameter-rich functional forms may contain implausible implications, which are hidden from easy detection. Further complex transformations may make it laborious to compute and assess the economic effects of interest (for example, elasticity of substitution). Therefore, it is better to choose functional forms in which the parameters have an intrinsic and intuitive economic interpretation, and in which the functional structure is clear.

c) Computational Ease

Historically, systematic multivariate empirical analysis has been confirmed to be linear (parameters) in a statistical model for computational reasons. While the current computational technology makes a direct estimation of non-linear forms feasible, linear parameter systems have a computation cost advantage, and have, in addition, the advantage of more fully developed statistical theory. The tradeoff between the computational requirements of a functional form and the thoroughness of empirical analysis should be weighed carefully in the choice of a model.

d) Interpolative Robustness

Within the range of the observed data, the chosen functional form should be well behaved, displaying consistency with maintained hypotheses such as positive marginal products or convexity. If these properties must be checked numerically, then the form should admit convenient computational procedures for this purpose.

e) Extrapolative Robustness

The functional form should be compatible with maintained hypotheses outside the range of observed data. This is a particularly important criterion for forecasting applications.

In the light of the above five criteria, the most appropriate functional form will be selected. The analysis will permit an examination of the interregional resource use differences among different farm categories in the scope of increasing production and employment in the agricultural sector in Sindh. At the level of policy, this study will seek to contribute and intend to make a more accurate assessment of the investment priorities in the distribution of additional resources to different farm categories in different districts, and will provide guidelines to achieve rapid growth in the agricultural sector in different irrigated regions of the Left and Right Banks of the Indus River in Sindh.

F. Net Benefits of Producing Major Crops in the Sindh Province

The cost of producing wheat, rice, sugarcane and cotton crops in each of the canal commands (already mentioned) were estimated to evaluate the net benefits accruing from different crops in different canal commands of the Lower Indus Basin in Sindh. To calculate the cost of the production of the major crops, all of the variable costs incurred (i.e. cost of land preparation, cost of seed bed preparation, cost of seed, irrigation cost, fertilizer cost, labor cost and other chemical and herbicide costs, excluding the land rent) were added to calculate the total cost of production for each specific crop on each farm. To estimate the Gross Income, the total farm crop production for the specific crop is measured in value terms. The crop output is defined as the sum of the monetary value of the total specific crop produced on the farm during the survey year. In this study, only the wheat, rice, sugarcane and the cotton crops have been taken for detailed investigation. Farmers were asked to give their best estimates about the production of the major crops on their farms.

The gross return of each crop per farm consisted of the value of the crop output. To measure the total farm crop output in value terms, per 40 kg of crop output received by the farmers at the farm gate was used. The value of the by-product was also added to determine the gross income estimates. In order to calculate the net benefits per farm from each of the crops, the total variable costs for each specific crop were deducted from the gross revenue per farm for that specific crop. The net benefits per farm for each of the major crops are calculated at the canal command level.

III FARMING SYSTEM IN SINDH

The Sindh Province stretches over an area of about 14.09 Mha; However, its shifting and variable rainfall patterns and incomplete land survey prevent a reliable classification and estimation of the current land use. Out of this area, 3.08 Mha are classified as current fallow, 1.39 Mha as cultivable waste, 0.68 Mha as forests, and 6.23 Mha as uncultivable land. These broad categories mask the extent of utilized and under-utilized areas suitable for various crops. Nonetheless, about 5.78 Mha are officially estimated as currently under cultivation (Govt. of Sindh 1995)[2]. The important characteristics of different attributes (of Sindh agriculture) used in the current study are described in the forthcoming sections.

A Climate

The climate of the Sindh Province can simply be described as arid and hot; nowhere in this province does the average rainfall exceed 260 mm, while mean maximum temperature generally exceeds 100° F. December to February is cool; the hottest period is from March to June. The humidity is low and increases as the sea breeze becomes dominant. The monsoon season is from July to mid-September. The high temperatures, low rainfall and low humidity that are general throughout the province provide a natural constraint to agricultural development in the absence of irrigation, and their effect is enhanced in the south-eastern part of the province by the high winds that blow for much of the year. In the irrigated areas, the climate is suitable for a variety of crops.

B. Temporal Changes since 1960 and Current Status of Sindh Agriculture

1) Farms and Farm Area

Tables 4 and 5 show the number of farms and area operated by different farm categories in the Sindh Province at the district level during 1960 to 1990. They show that overall, the number of farms in the Sindh Province increased by 10, 16 and 18 percent when compared to the number of farms during 1960. In the case of the Left Bank area (LBA) the number of farms increased during 1972 and 1980 by 11 and 14 percent respectively, when compared to 1960 and decreased to about 3 percent in 1990 when compared to the total farms on the Left Bank during 1980. In the case of the area on the Right Bank (RBA) of the Indus River, the total number of farms increased by 7, 21 and 36 percent, respectively, during 1972, 1980 and 1990 when compared to total number of farms on the RBA during 1960. Table 5 shows the total farm area in Sindh decreased by 11 percent from 1960 to 1990. These tables also show that 26 percent of small farms occupied only 5 percent of the farm area in the 1960s when compared to about 33 percent of the farms, which occupied 9 percent of the farm area in the Sindh during the1990s. The mid-size farmers represented 61 percent and owned 56 percent of the land in the 1990s. The large farms (10 ha and above) composed about 6 percent of the total farms, but possessed 35 percent of the total land area in 1990 (Govt. of Sindh, 1995).

[2] Government of Sindh "Development Statistics of Sindh" Bureau of Statistics, Planning and Development Department, P.O. Box No. 3879 Kehkashan Clifton, Govt. of Sindh, Karachi 6, Pakistan.

Table 4. Total Farm Numbers and its Distribution in the Sindh Province (1960-90).

District	Farm Number				Percentage of Farms with respect to 1960			
	1960	**1972**	**1980**	**1990**	**1960**	**1972**	**1980**	**1990**
Badin			57005	62813				
Hyderabad	86673	113284	65890	61874	100	131	76	71
Khairpur	49985	64449	63002	69430	100	129	126	139
Naushehro Feroze				32327				
Nawabshah	74989	87154	83468	19153	100	116	111	26
Sanghar	52324	62612	56698	51152	100	120	108	98
Sukkur	83880	107200	61989	67492	100	128	74	80
Tharparkar	100086	64197	122424	124795	100	64	122	125
LBA	**447937**	**498896**	**510476**	**489036**	**100**	**111**	**114**	**109**
Dadu	55625	60391	52704	63224	100	109	95	114
Jaccobabad	54341	70344	64341	81575	100	129	118	150
Larkana	82229	72080	71129	88787	100	88	87	108
Shikarpur	0	0	39962	28832				
Thatta	36340	42273	48668	48566	100	116	134	134
RBA	**228535**	**245088**	**276804**	**310984**	**100**	**107**	**121**	**136**
Sindh	**676472**	**743984**	**787280**	**800020**	**100**	**110**	**116**	**118**
Small	26	18	25	33	100	69	96	127
Medium	62	73	68	61	100	118	110	98
Large	12	9	7	6	100	75	58	50

Table 5. Total Farm Area and its Distribution in the Sindh Province (1960-90).

District	Farm Area Total (Ha)				Percentage of Farm Area with respect to 1960			
	1960	1972	1980	1990	1960	1972	1980	1990
Badin	0	0	355087	323808	0	0	0	0
Hyderabad	555548	790402	320199	302073	100	142	57	54
Khairpur	248554	268645	214781	180915	100	108	86	72
Naushehro Feroze	0	0	0	107049	0	0	0	0
Nawabshah	422968	441859	356499	123861	100	104	84	29
Sanghar	343220	355613	314343	334845	100	103	91	97
Sukkur	324301	422525	221843	193503	100	130	68	59
Tharparkar	914595	381743	795841	820836	100	41	87	89
LBA	**2809186**	**2660787**	**2578592**	**2084816**	**100**	**95**	**92**	**74**
Dadu	291373	307160	236865	236172	100	105	81	81
Jaccobabad	286923	285103	258549	282584	100	99	90	98
Larkana	294486	268136	224159	261337	100	91	76	88
Shikarpur	0	0	118282	76270	0	0	0	0
Thatta	212473	262324	244259	219416	100	123	114	103
RBA	**1085255**	**1122723**	**1082113**	**1377851**	**100**	**103**	**100**	**127**
Sindh	**3894442**	**3783510**	**3660705**	**3462667**	**100**	**97**	**94**	**89**
Small (%)	5	5	6	9	100	100	120	180
Medium(%)	53	63	60	56	100	119	113	106
Large(%)	42	32	34	35	100	76	81	83

2) Cultivated Area

The inter-temporal changes in the total cultivated area in the thirteen districts of Sindh are given in Table 6. The total cultivated area was reported to be 3.14 Mha in 1960, 3.2 Mha in 1972, 3.13 Mha in 1980 and 2.85 Mha during 1990. The proportion of cultivated area in these districts reduced by 9 percent during 1960-1990. On the LBA, the total cultivated area remained the same during 1972 when compared to the 1960's, but reduced by 16 percent during 1990 when compared to 1960. Cultivated areas in the RBA increased by 6 and 8 percent during 1972 and 1990 respectively, when compared to the cultivated area on the RBA during 1960. Table 6 shows that similar to the farm area, a higher proportion of cultivated area represents the medium and large farms when compared to the small farms during all the census years (1960-90). The temporal comparison shows that the cultivated area on the small and medium farms has increased by 43 and 3 percent, respectively, during the 1990s when compared to 1960, but on the large farms the cultivated area has decreased by 14 percent during 1960-90.

Table 6. Proportion of Cultivated to Total Farm Area and its Distribution in the Sindh Province (1960-1990).

Districts	Cultivated Area				Percentage of cultivated area with respect to 1960			
	1960	1972	1980	1990	1960	1972	1980	1990
Badin	0	0	284926	235922	0	0	0	0
Hyderabad	462941	633071	273822	251600	100	137	59	54
Khairpur	204924	246401	201439	172884	100	120	98	84
Naushehro Feroze	0	0	0	90646	0	0	0	0
Nawabshah	356045	404527	329370	111138	100	114	93	31
Sanghar	289658	310402	263407	245756	100	107	91	85
Sukkur	278071	392831	202395	172477	100	141	73	62
Tharparkar	700919	314401	705886	655422	100	45	101	94
Left Bank	**2292559**	**2301632**	**2261244**	**1935845**	**100**	**100**	**99**	**84**
Dadu	222083	220548	168750	186632	100	99	76	84
Jaccobabad	222578	275679	222215	257027	100	124	100	115
Larkana	256001	229679	202855	252623	100	90	79	99
Shikarpur	0	0	112964	74418	0	0	0	0
Thatta	155166	180406	164686	151942	100	116	106	98
Right Bank	**855827**	**906313**	**871469**	**922642**	**100**	**106**	**102**	**108**
Sindh	**3148386**	**3207945**	**3132714**	**2858487**	**100**	**102**	**100**	**91**
Small	7	5	7	10	100	71	100	143
Medium	58	70	65	60	100	121	112	103
Large	35	25	28	30	100	71	80	86

Percentage of Cultivated Area in each Farm Category

3) Tenure Classification of Farms

The total number of farms in 13 districts of Sindh were 0.64 million in 1960, 0.70 million in 1972, 0.78 million during 1980 and 0.75 million in 1990. The number of total farms increased from 0.64

million in 1960 to 0.75 million in 1990. The ratio of small-owner farms in Sindh has increased from 29 percent in 1960 to 64 percent in 1990. Table 7 shows that the percentage of medium and large-owner farms in Sindh have increased from 17 and 48 percent, respectively, in 1960 to 48 and 76 percent for medium and large farms, respectively, in 1990. The percentage of owner-cum-tenant farms has remained the same to about 2 percent from 1960 to 1990, but the percentage of both medium and large owner-cum-tenant farms has increased from 9 and 21 percent, respectively, in 1960 to 13 and 16 percent in 1990. During 1960 about 69 percent of the small farms were categorized as tenant farms; these farms decreased to 47 percent in 1972 and their ratio further decreased to 42 and 34 percent in 1980 and 1990, respectively. The participation of medium and large tenant farms also decreased from 75 percent in 1960 to 43 percent in 1990, and the participation of large tenant farms decreased from 32 percent to 8 percent during 1990.

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Table 7. Farm Size and Tenure in the Sindh Province (1960-1990)

	Owner Farms				Owner-cum-Tenant				Tenant			
	1960	1972	1980	1990	1960	1972	1980	1990	1960	1972	1980	1990
Hyderabad	10504	29540	20481	23551	4636	8110	3611	2912	71533	75601	41800	35408
Khairpur	18669	24676	33527	54318	8392	15145	11154	6092	22924	24628	17312	9020
N Feroz	0	0	24820	23573	0	0	9035	3429	0	0	49617	5327
Nawabshah	13445	19024	40350	14045	5659	10194	9343	1176	55885	57928	13311	3935
Sanghar	4616	10177	14300	18060	1416	2590	2651	1356	46292	49845	39748	31730
Sukkun	12159	22096	143	43085	12022	25356	2651	8293	59699	59733	39748	16115
Tharparkar	36765	11598	45607	65980	11417	2639	11863	7656	51904	49946	64954	51160
LBA	***96158***	***117111***	***199961***	***276091***	***43542***	***64034***	***53663***	***33615***	***308237***	***317681***	***299408***	***179326***
Dadu	13504	18789	31249	31751	4817	9985	5470	6265	37204	31617	15983	25209
Jaccobabad	7665	11542	20391	22460	1731	5975	6588	5950	44945	52820	37360	53168
Larkana	11216	17215	29228	34115	7077	11319	9943	11722	63936	43544	31953	42951
Shikarpur	0	0	20477	13859	0	0	4560	1470	0	0	14928	13502
Thatta	6643	11181	16733	26183	2332	5116	6653	1853	27365	25974	25285	20534
RBA	***32385***	***47546***	***101345***	***102185***	***13625***	***27279***	***26561***	***25407***	***146085***	***127981***	***100224***	***134830***
Sindh	**128543**	**164657**	**301306**	**378276**	**57167**	**91313**	**80224**	**59022**	**454322**	**445662**	**399632**	**314156**
Small (%)	29	50	52	64	2	4	3	2	69	47	42	34
Medium (%)	17	20	37	48	9	14	12	13	75	67	51	43
Large (%)	48	54	67	76	21	27	23	16	32	19	10	8
	[illegible]			[illegible] 1960	[illegible]			[illegible] 1960	[illegible]			[illegible] 1960
Hyderabad	100	281	195	224	100	175	78	63	100	106	58	49
Khairpur	100	132	180	291	100	180	133	73	100	107	76	39
N Feroz												
Nawabshah	100	141	300	104	100	180	165	21	100	104	24	7
Sanghar	100	220	310	391	100	183	187	96	100	108	86	69
Sukkur	100	182	1	354	100	211	22	69	100	100	67	27
Tharparkar	100	32	124	179	100	23	104	67	100	96	125	99
LBA	100	122	208	287	100	147	123	77	100	103	97	58
Dadu	100	139	231	235	100	207	114	130	100	85	43	68
Jaccobabad	100	151	266	293	100	345	381	344	100	118	83	118
Larkana	100	153	261	304	100	160	140	166	100	68	50	67
Shikarpur												
Thatta	100	168	252	394	100	219	285	79	100	95	92	75
RBA	100	147	313	316	100	200	195	186	100	88	69	92
Sindh	100	128	234	294	100	160	140	103	100	98	88	69

4) Land Use Intensity across Farm Size Groups

Table 8 shows that overall land use intensity in the Sindh Province was 76 percent in 1960, 85 percent in 1972, 87 percent in 1980 and 86 percent in 1990. This varied from 87 percent in 1960, 96 percent in 1972, 93 percent 1980 and 91 percent in 1990 (in farms of less than 2 ha). Medium farms (2 ha to 10 ha) varied from 88 percent in 1960, 94 percent in 1972, 93 percent in 1980 and 91 percent in 1990. The land use intensity was reported to be 54 percent, 66 percent, 69 percent and 70 percent on large farms of 10 ha and above during 1960, 1972, 1980 and 1990, respectively. The intensity of land use in Sindh was reported to be higher for tenant-operated farms (93 percent), which decreased to 81 percent for owner-cum-tenant farms and 79 percent on owner-operated farms during 1990.

Table 8. Temporal Changes in the Land Use Intensity across Farms in the Sindh Province (1960 - 90).

Farm size (ha)	1960	1972	1980	1990
Under 0.5	82	95	97	96
0.5 - 1.0	89	97	97	97
1.0 - 2.0	91	97	97	96
Small	87	96	97	96
2.0 - 3.0	90	97	97	95
3.0 - .7.0	89	95	95	92
5.0- 10.0	85	90	88	85
Medium	88	94	96	91
.10.0 – 20	76	79	81	79
20.0 - 60	57	64	73	69
60.0 and Above	29	55	54	61
Large	54	66	69	70
Overall	76	85	87	86

Source: Agri. Census of Pakistan, 1960, 1972, 1980, and 1990.

5) Cropping Intensity across Farm Size Groups

Table 9 shows that the overall cropping intensity of the Sindh Province was 124 percent, 123 percent, 135 percent and 146 percent during 1960, 1972, 1980 and 1990, respectively. This varied from 134 percent, 148 percent, 156 percent and 167 percent in farms of less than 2 ha during 1960, 1972, 1980 and 1990, respectively. In the case of the medium farms (2 ha to 10 ha), the cropping intensity varied from 128 percent during 1960 and 1972 to 138 percent, and 148 percent during 1980 and 1990, respectively. In the farms of 10 ha and above, the cropping intensity was reported to be 111 percent, 94 percent, 111 percent and 127 percent during 1960, 1972, 1980 and 1990, respectively. The intensity of cropping in Sindh during 1990 was almost the same (136 and 138 percent on owner-farms and owner-cum-tenant farms, respectively), but increased to 148 percent on tenant-operated farms.

Table 9. Cropping Intensity across Farms in the Sindh Province (1960 - 90).

Farm size	1960	1972	1980	1990
Under 0.5	137	156	152	176
0.5 - 1.0	135	143	159	166
1.0 - 2.0	131	144	157	159
Small	134	148	156	167
2.0 - 3.0	133	141	155	159
3.0 - .5.0	128	126	135	141
5.0- 10.0	122	116	123	130
Medium	128	128	138	143
.10.0 – 20	115	104	114	126
20.0 - 60	111	93	109	129
60.0 and Above	108	86	111	127
Large	111	94	111	127
Over All	124	123	135	146

Source: Agri. Census of Pakistan, 1960, 1972, 1980, and 1990.

In Sindh, the problem of land utilization has two aspects, viz., the level of utilization of cultivable area, i.e., the proportion of cultivable area actually cultivated, and the intensity with which the cultivated area is being utilized. The intensity of cultivation can be defined at least in two ways, the number of times the cultivated area is cropped within a year and the level of application of the current or complementary inputs, such as labor, fertilizer, manure, irrigation, etc. The level of agricultural production depends primarily on how well the almost irrelaxable constraint (the land) is utilized. In this context it becomes important to identify the economic factors responsible for the under-utilization of land input. Since the orchards remain in the field during the Kharif and Rabi[3] seasons, the orchard area was added to the gross cropped area reported in the census in order to compute the real gross cropped area.

6) Adoption of Improved Seed across Farm Size Groups

Improved and healthy seed is a prerequisite for achieving increased crop yields. During the 1970s, the Government of Sindh established a seed industry to produce certified seed. Since then, efforts have been accelerated to streamline its distribution to ensure the timely availability of high-yielding varieties (HYV) of major crops including wheat and cotton, and efforts were made to bring as much area as possible under the improved seeds. During 1981-82 the percentage of area under HYV in Sindh, when compared to the total area for wheat and cotton, was 68 percent and 70 percent, respectively. This share increased to 95 percent and 94 percent, respectively, for the area under HYV of wheat and cotton during 1994-95. The area under HYV of wheat during 1971-72 was 83 and 16 percent on small and medium farms, respectively. Only 1 percent of the large farms planted the HYV of wheat on their farms during 1971-72 (GoP 1972). According to the 1980 Census of Agriculture, the percentage area of small, medium, and large farms under HYV of wheat was 9 percent, 70 percent and 21 percent, respectively (GoP, 1980).

[3] Summer and winter seasons.

7) Fertilizer Use across Farm Size Groups

Fertilizer is the single-most important input, and contributes substantially towards an increase in crop yields. In Sindh, the introduction of fertilizer during the 1960s was a new experience. Table 4.6 shows that during 1960 only 4 percent of the farms in Sindh reported the use of fertilizers on their farms. The farms reporting the use of fertilizer constituted only 1 percent on the RBA and about 6 percent on the LBA. This percentage increased to about 60 percent during 1972, and about 63 and 73 percent of the farms reported use of fertilizer on their crops during 1980 and 1990, respectively. A higher percentage of farms (77 %) located on the RBA reported the use of fertilizer when compared to the farms located on the LBA (70 %) during 1990. These farms used fertilizer on about 54 percent of the area under crops in the Kharif season and on about 44 percent of the area under crops during the Rabi season.

Table 10. Farms Reporting the Use of Fertilizer across Districts in the Sindh Province (1960-90).

Districts	Total Number of Farms				Farms Reporting use of Fertilizer				Farms reporting fertilizer (Percentage)			
	1960	1972	1980	1990	1960	1972	1980	1990	1960	1972	1980	1990
Badin	0	0	57005	62815	0	0	38446	53265			67.4	84.8
Hyderabad	86673	113251	65890	61874	4377	79407	44048	47929	5.1	70.1	66.9	77.5
Khairpur	49985	64449	63002	69429	5066	9893	48630	48218	10.1	15.4	77.2	69.4
Naushehro Feroze	0	0	0	32326	0	0	0	28652				88.6
Nawabshah	74989	87146	83468	19153	8255	57553	65819	14964	11.0	66.0	78.9	78.1
Sanghar	52324	62612	56698	51152	8473	35105	47216	47573	16.2	56.1	83.3	93.0
Sukkur	83880	107185	61989	67489	275	52754	41842	58134	0.3	49.2	67.5	86.1
Tharparkar	100086	64183	122424	124795	1268	51222	45344	46954	1.3	79.8	37.0	37.6
LBA	**447937**	**498826**	**510476**	**489033**	**27714**	**285934**	**331345**	**345689**	**6.2**	**57.3**	**64.9**	**70.7**
Dadu	55625	60391	52704	63224	2058	35265	25856	40482	3.7	58.4	49.1	64.0
Jaccobabad	54341	70337	64341	81574	0	39499	42795	72849	0.0	56.2	66.5	89.3
Larkana	82229	72078	71129	88786	223	4654	57105	80787	0.3	6.5	80.3	91.0
Shikarpur	0	0	39962	28832	0	0	29340	20633			73.4	71.6
Thatta	36340	42271	48668	48567	21	78962	7434	26936	0.1	186.8	15.3	55.5
RBA	**228535**	**245077**	**276804**	**310983**	**2302**	**158380**	**162530**	**241687**	**1.0**	**64.6**	**58.7**	**77.7**
Sindh	**676472**	**743903**	**787280**	**800016**	**30016**	**444314**	**493875**	**587376**	**4.44**	**59.73**	**62.73**	**73.42**

The consumption of nitrogen, phosphate and potash fertilizer was 87.5, 8.1 and 0.3 thousand nutrient tons, respectively, in 1971-72 and increased to 417.8, 94.6 and 8.1 thousand nutrient tons, respectively, during 1995-96. The use of fertilizer remained limited to the irrigated areas and also for major crops. According to the 1972 Census of Agriculture, 17 percent of small, 75 percent of medium, and 8 percent of large farms reported the use of fertilizer on their farms. According to the 1990 Census of Agriculture, the use of fertilizer on small farms increased to 34 percent, while it decreased on medium and large farms to 60 percent and 5 percent, respectively. The reason for a higher fertilizer use on small farms may be that small farms used a larger amount of manure (easily available due to a higher livestock population) on their farms compared to medium and large farms. Table 4.6 also show the district-wise use of fertilizer on the farms in 13 districts of Sindh (the remainder of the districts were non-existent during the 1960s), and shows that during 1960 the fertilizer was only used by the farms located in Hyderabad, Khairpur, Nawabshah, Sanghar and Dadu. The percentage of farms reporting the use of fertilizer ranged up to 16 percent. During 1990 all the farms reported the use of fertilizer on their farms, which ranged from 37 percent of the farms reporting the use of fertilizer in Tharparkar District to 93 percent of the farms reporting the use of fertilizer on their farms in district Sanghar.

8) Irrigation Use across Farm Size Groups

The Barrage Irrigation System was introduced in Sindh in 1932 with the construction of the Sukkur Barrage. Later on, the Kotri and the Guddu Barrages completed the system's present day form which involves a complex network of 3 barrages, 14 canals on both the Left and the Right Bank of the Indus River, distributaries and minors to harness the water to the farmers' fields. Table 11 shows that during 1959-60 the total canal-irrigated area was 2.94 million hectares; in the total canal-irrigated area the share of small farms was only 7 percent, while the share of medium and large farms was 64 percent and 29 percent, respectively. During 1989-90, canal-irrigated area decreased to 2.35 million hectares, with the share of 12 percent, 60 percent, and 28 percent on small, medium and large farms, respectively. In addition to this barrage system, about 0.02 million hectares were irrigated by the supplemental irrigation provided by tubewells. The total area irrigated by tubewells increased to 0.44 million hectares during 1990.

Table 11. Total Cultivated Area Irrigated and its Distribution across Farm Categories in theSindh Province (1960-90).

(Ha)

Farm size	Irrigated Area				Irrigated area as percentage of total Cultivated Area			
Ha	**1960**	**1972**	**1980**	**1990**	**1960**	**1972**	**1980**	**1990**
Under 0.5	1667	1204	8047	9838	91	98	95	99
0.5 - 1.0	28385	15186	31608	50928	91	97	93	97
1.0 - 2.0	150679	37576	177614	226062	91	97	95	96
Small %	**7**	**19**	**9**	**12**				
2.0 - 3.0	221041	48939	329457	367432	90	95	93	93
3.0 - .5.0	509060	99317	797576	588361	90	97	90	85
5.0- 10.0	862037	63101	604807	456651	87	96	76	72
Medium %	**64**	**74**	**69**	**60**				
10.0 – 20	486517	14132	272070	230210	73	94	60	67
20.0 - 60	158415	4612	194227	218876	43	93	62	76
60.0 and Above	73427	1004	110380	200676	70	97	80	90
Large %	**29**	**7**	**23**	**28**				
Total Sindh	2491229	285072	2525786	2349034	79	96	80	82

Source: Agricultural Census of Pakistan, 1960, 72, 80,90.

over the years. Table 14 depicts that according to the 1960 Census of Agriculture, about 22 percent of small farms, 67 percent of medium farms, and 11 percent of large farms were in debt. During 1990 this percentage was 27 percent, 65 percent, and 8 percent for small, medium and large farms, respectively.

11) Unutilized Land across Farm Size Groups

In Sindh agriculture, out of the canal-commanded area of 2.34 Mha, about 2.13 Mha was under irrigation during 1989-90. The remaining over 22 percent of the total farm area were not cultivated for raising crops. The analysis of the 1990 census shows that as the size of the holding increases, the proportion of area unused also increases. Also shown is that out of the total uncultivated area, 10 percent are located on small farms, 51 percent on medium farms, and 39 percent on large farms.

Table 14 The Number of Households under Debt across Districts in the Sindh Province (1960-1990).

Districts	Total Farm Households				No. of Households under Debt				Percentage of Households under Debt			
	1960	1972	1980	1990	1960	1972	1980	1990	1960	1972	1980	1990
Badin	0	0	57544	62894	0	0	14111	26940			25	43
Hyderabad	86683	115449	66616	62627	45480	60033	20331	14862	52	52	31	24
Khairpur	49985	65754	63579	69571	18887	30247	13704	9687	38	46	22	14
Naushehro.Feroz	0	0	0	32571	0	0	0	4491				14
Nawabshah	74989	88731	84171	19301	14059	39042	11955	2884	19	44	14	15
Sanghar	52324	63399	57235	51320	23487	29164	16525	30056	45	46	29	59
Sukkur	83880	111382	63662	67685	28041	55691	10122	22360	33	50	16	33
Tharparkar	100086	64903	123494	125430	28352	33750	34168	41972	28	52	28	33
LBOD	447947	509618	516301	491399	158306	247926	120916	153252	35	49	23	31
Dadu	55625	61457	52978	63240	19536	35030	5321	6300	35	57	10	10
Jaccobabad	54341	70957	65334	81659	10585	36188	16318	20949	19	51	25	26
Larkana	82229	72386	71386	88976	26181	34021	7923	8294	32	47	11	9
Shikarpur	0	0	40188	28834	0	0	6687	1689			17	6
Thatta	36340	43328	50124	48740	16599	30763	17983	11684	46	71	36	24
RBOD	228535	248128	280010	311449	72901	136003	54232	48916	32	55	19	16
Sindh	676482	757746	796311	802848	231207	383929	175148	202168	34	51	22	25

IV Spatial and Temporal Variations in the Area and Productivity of Major Crops in the Sindh Province

The area under different crops fluctuates with climatic factors, marketing situations, the availability of irrigation water and inputs. If one crop shares more area in one year, it may increase or decrease the next year due to high prices. For example, the increasing demands from sugar mills and high sugarcane prices may result in an increased in area under sugarcane, but a lower response will mean a decrease. A similar situation also prevails in the case of cotton and other crops. Some respondents said that they avoid growing the cotton crop due to price uncertainties, pest attacks and weather threats, etc.

Most respondents informed that the yield of their crops has decreased due to more than one reason. The most frequently told reasons were high watertable, and drainage problems. Other factors of low yield they described were unavailability of inputs at the right time, financial constraints and shortage of irrigation water, pest attacks, an increasing problem of salinity, and climatic conditions. A few respondents said that their yields had increased due to better management, favorable climate, more irrigation water and a lower watertable. The area, production and yield of some important crops of Sindh are given here.

In terms of both, output and employment, the major agricultural crops on the Left and the Right Banks of the Indus River in the Sindh Province are wheat, cotton, rice and sugarcane. The total cultivated area, production and yield per hectare of wheat, cotton, rice and sugarcane in the Sindh Province is reported in Figures 2-5. Out of the total for wheat, cotton, rice and sugarcane in Pakistan (i.e. 16.9 million tons, 10.6 million bales, 1.96 MT and 45.23 MT, respectively), about 2.29 MT, 1.69 MT, 1.86 million bales and 13.74 MT, respectively, have been produced in the Sindh Province during 1995-96 (ASP 1995-96). Figures 2, 3, 4, 5, 2(a), 3(a), 4(a) and 5(a) show the changes in the productivity of these crops from 1947-48 to 1995-96.

1) District-wise Temporal Variation in the Area, Production and Productivity of Wheat in the Sindh Province

Figure 2 shows that about 1.1 Mha of the wheat crop was sown in the Sindh Province during 1995-96 and constituted about 13 percent of the total wheat acreage within Pakistan (8.4 Mha). The changes in the wheat productivity over time, depicted in Figure 2 (a), shows that the wheat yield has increased in Sindh from 0.72 tons/ha to 2.12 tons/ha from 1947-48 to 1995-96, respectively. The district-wise spatial and temporal differences in the productivity of the wheat crop are depicted in Figure 2(b), where two distinct trends can be observed. The first is an increasing trend in the productivity in Khairpur, Jaccobabad, Dadu, Nawabshah, Sanghar, Larkana, Tharparkar and Hyderabad Districts during the 1970s, which persisted until the mid-1980s. Secondly, in the case of Districts Sukkur, Shikarpur, Thatta and Badin, the productivity of wheat demonstrated a declining trend during the 1990s. The increase in productivity was the result of the new innovations introduced through the green revolution, like chemical fertilizers and the distribution of high yielding variety seeds. However, in recent years, the wheat output has been low; during 1995-96 the average

Figure 2. Trends in Production of Wheat in the Sindh Province.

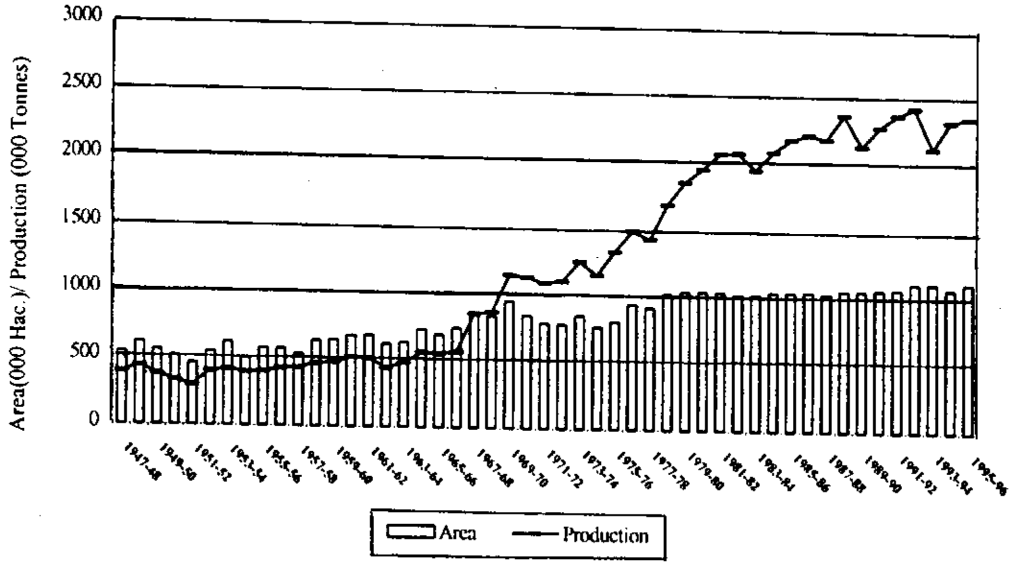


Figure 2 (a). Trends in Yields of Wheat in the Sindh Province (1947-1996).

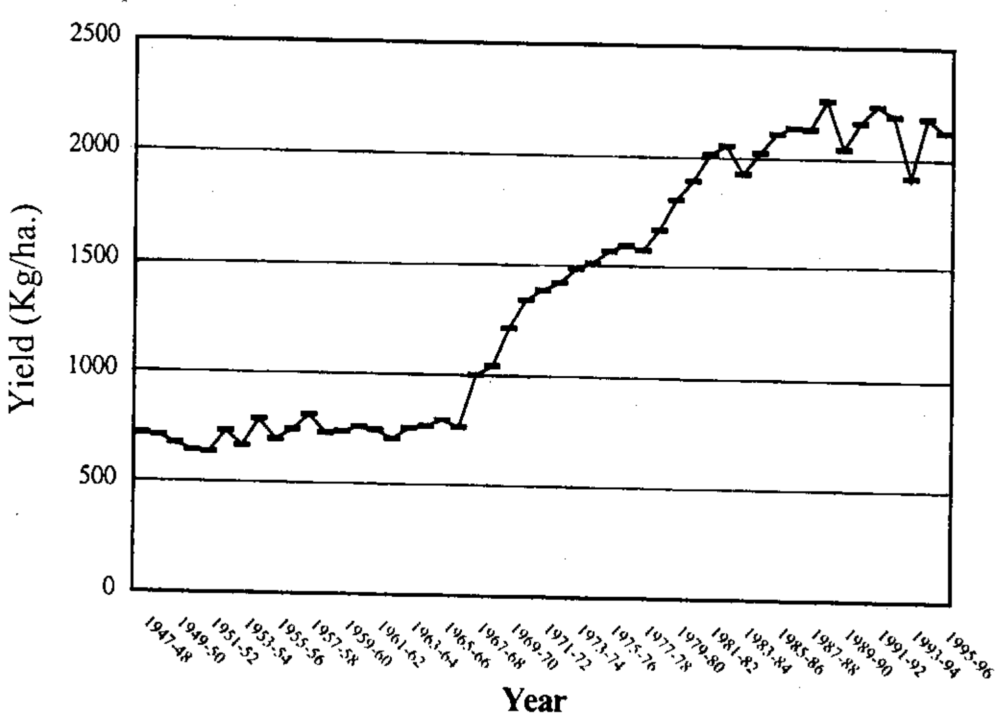
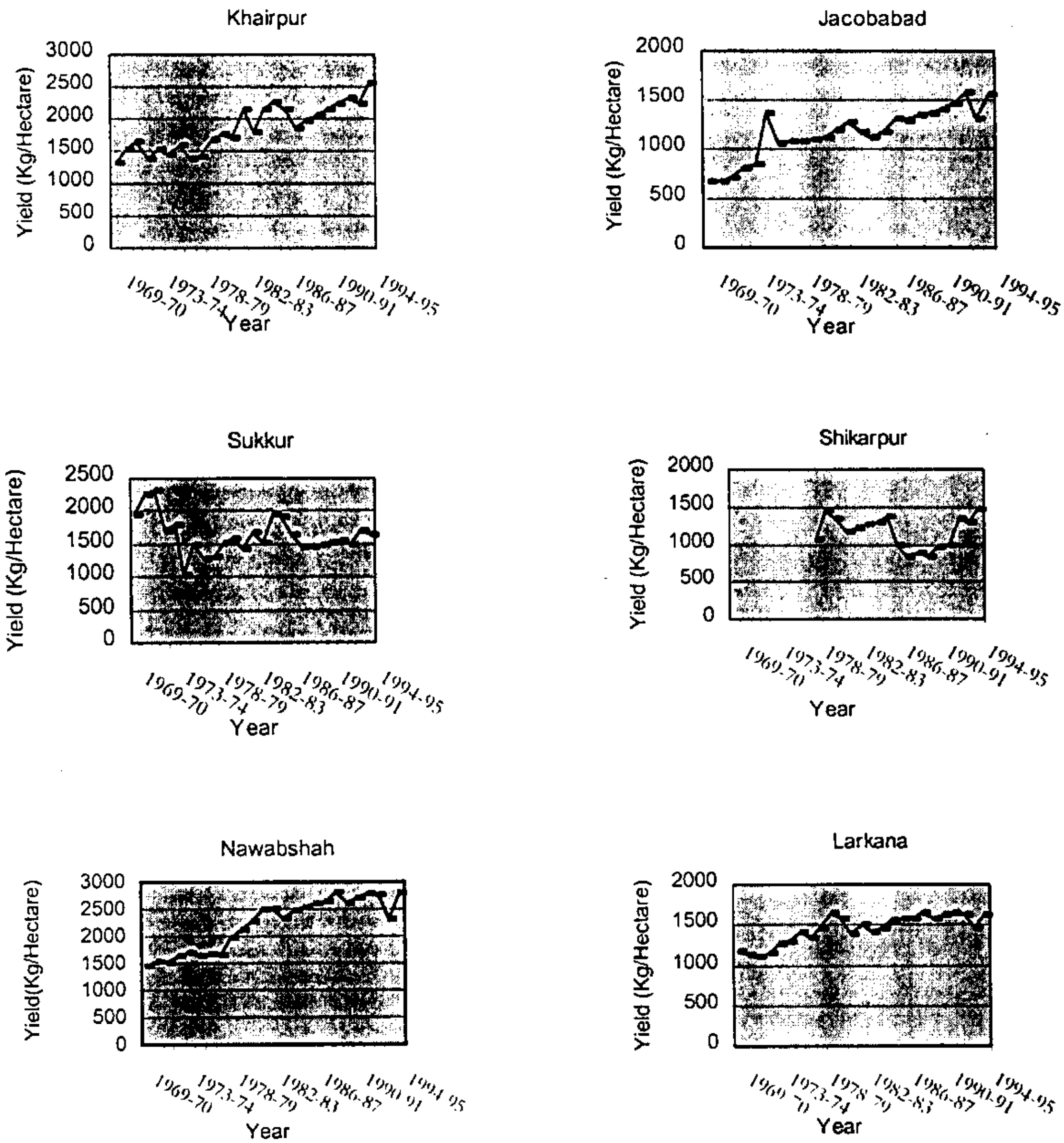
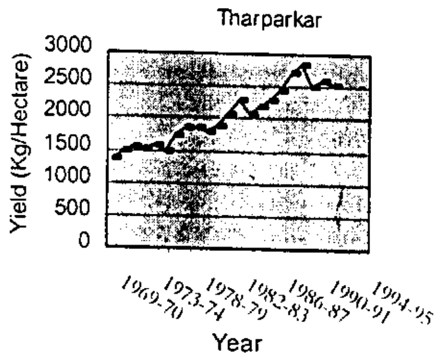
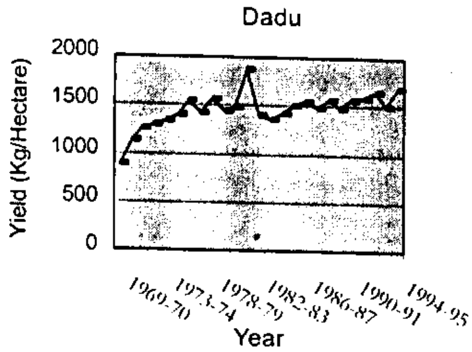
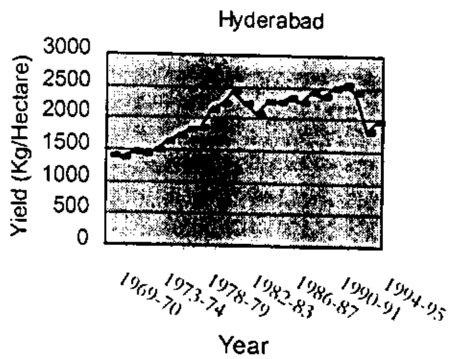


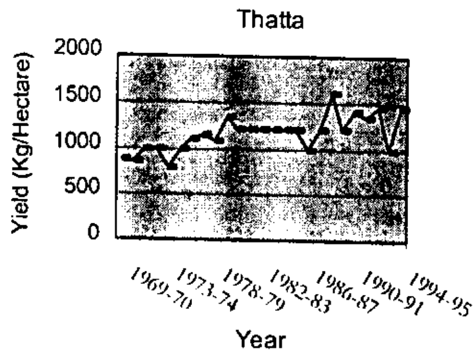
Figure 2(b). District-wise Spatial and Temporal Variation in Yields of Wheat Crop in the Sindh Province.

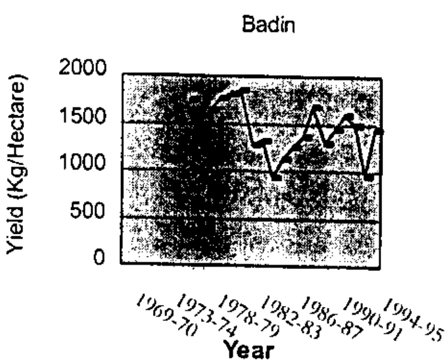


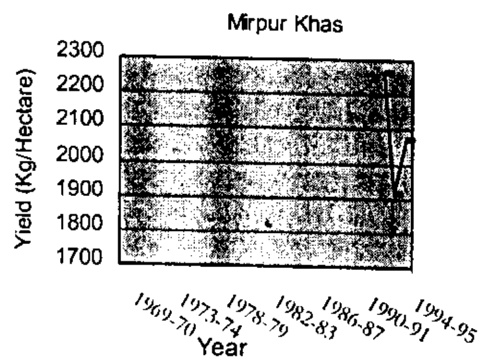

Tharparkar
Yield (Kg/Hectare)
3000
2500
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Dadu
Yield (Kg/Hectare)
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Hyderabad
Yield (Kg/Hectare)
3000
2500
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Thatta
Yield (Kg/Hectare)
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Badin
Yield (Kg/Hectare)
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Mirpur Khas
Yield (Kg/Hectare)
2300
2200
2100
2000
1900
1800
1700
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year

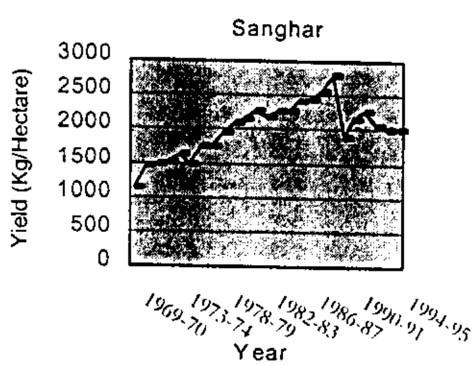

Sanghar
Yield (Kg/Hectare)
3000
2500
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year

Table 15. Regression Results Relating the Production of Wheat with Respect to the Temporal and Spatial Changes in the Yield and Area of the Wheat Crop in the Sindh Province.

Districts	Constant	Yield	Area	Yield80	Area80	Yield90	Area90	Ad-R Square	F-cal	DF Total
Badin	-1.67		1.74	0.02	-1.04	0.03	-1.30	0.95	101.86	24
	(2.35)		(0.09)	(0.007)	(0.27)	(0.01)	(0.35)			
Dadu	-91.33	0.070	1.35				0.021	0.99	3583.32	24
	(2.09)	(.001)	(0.03)				(0.008)			
Hyderabad	-183.39	0.110	1.65	-0.0016				0.99	1446.52	24
	(7.91)	(0.002)	(0.05)	(0.001)						
Jaccobabad	-48.18	0.050	0.93	-0.007	0.20			0.97	224.31	24
	(4.99)	(0.002)	(0.07)	(0.003)	(0.07)					
Khairpur	-156.18	0.097	1.63			0.003		0.99	3143.75	24
	(4.66)	(0.003)	(0.07)			(0.001)				
Larkana	-79.05	0.057	1.36			-0.005	0.15	0.99	870.08	24
	(3.67)	(0.001)	(0.04)			(0.003)	(0.07)			
Mirpurkhas	-0.06					0.08	0.65	0.99	5029.11	24
	(0.85)					(0.01)	(0.25)			
Nawabshah	-309.19	0.193	1.60				0.077	0.99	5747.33	24
	(7.70)	(0.004)	(0.07)				(0.014)			
Sanghar	-233.57	0.095	2.34	0.060	-0.86			0.99	5393.29	24
	(5.19)	(0.007)	(0.11)	(0.008)	(0.12)					
Shikarpur	-0.274	0.033	-1.23	-0.019	1.67		0.97	0.98	272.38	24
	(0.65)	(0.005)	(0.39)	(0.005)	(0.40)		(0.18)			
Sukkur	-155.57	0.097	1.64		-0.59	0.04		0.99	2811.78	24
	(4.98)	(0.004)	(0.06)		(0.13)	(0.01)				
Tharparkar	-7.50	0.041	1.11	0.028		0.02		0.97	250.33	24
	(8.95)	(0.013)	(0.18)	(0.005)		(0.01)				
Thatta	-9.65	0.009	0.95	-0.005	0.98	-0.002	0.33	0.98	278.74	24
	(1.16)	(0.001)	(0.03)	(0.001)	(0.35)	(0.001)	(0.11)			

yield on the farmers' fields in the Sindh Province was recorded as 2.11 tons/ha when compared to 5.02 tons/ha reported on the experimental stations. Based on the IIMI farm survey, a majority of the farmers cited the high water table scarcity of irrigation water as the main reason behind low wheat yields. About 44 percent of the farms (mostly located in the canal command areas of Begari, Desert, Fuleli, Ghotki, Khairpur East, Khairpur West, Pinyari and Rice Canals) regarded the high watertable to be the contributor towards the lower yields of wheat. About 23 percent of the farms regarded the scarcity of irrigation water to be the reason for the low production of wheat.

The regression results pertaining to the trends in wheat production with respect to the area and productivity of the wheat crop at the district level in the Sindh Province are given in Table 15. After trying different functional relationships, the linear equation, in all of the cases, provided the best fit. All of the regression equations were statistically significant at the 99 percent level of confidence. The overall explanatory power (as shown by the adjusted R^2) was very high and all of the regression equations showed the expected signs as well as the magnitude of the estimated variables. For the Hyderabad, Jaccobabad, Shikarpur, Larkana and Thatta Districts, the increase in the wheat area is not accompanied by a consistent increase in productivity that initially increased during 1970, and thereafter, decreased between 1980 and 1990. In case of the Badin, Sanghar and the Sukkur Districts, the trend in the area under wheat shows a decline during the period 1980-90, and afterwards, the coefficient for the area under wheat (Area 91-95) increases. For the Larkana, Mirpurkhas, Nawabshah, Shikarpur and Thatta Districts, the coefficients for the area under wheat consistently show an increasing trend during the 1990s.

The coefficients for the overall trend in the wheat yield showed an increase during the 1980s in all of the districts, except Hyderabad, Jaccobabad, Shikarpur and Thatta. For the Badin District, the coefficients for the wheat yields also depict a decline in productivity during the 1990s due to the drainage problem, high watertable and the scarcity of irrigation water at the tail end. The farmers' perceptions about the reasons for the low productivity on their farms in the Sindh Province are being discussed in the next section of this volume.

2) District-wise Temporal Variation in the Area, Production and Productivity of Cotton in the Sindh Province

Cotton cultivation is comparatively more intense on the Left Bank of the Indus River in the Sindh Province. The area increased from an average of 0.34 Mha during the 1940s to an average of 0.67 Mha during the 1980s (Figure 3). This increase in the area was the result of increased canal water supplies during the 1980s. The other major factors responsible for the increase were the remunerative and stable price policies of the government. This increasing trend in the area was interrupted after 1988-89 when the virus attack ruined the cotton crop on a majority of the farms. Figure 3(a) shows the impact of this adversity across each successive year beyond 1988-89.

Regarding the cotton crop production, the stagnation also continues until 1991-92 is replaced by an increasing trend, contributed in part by the variety of improvements and more resolute pest scouting. The record level of production (1.86 million bales) in the Sindh Province was attained during 1995-96, after about six years of the virus attack. The temporal comparison of the cotton yield across districts in Sindh appears in Figure 3(b), whereby the districts of Khairpur, Sukkur and Nawabshah show an increasing trend in cotton productivity over time during 1947-48 to 1994-95. The inter-district variations in the cotton yields are depicted in Figure 3(b), wherein the yield varied every alternate year in almost all of the 13 districts of Sindh under study.

The district-level regression results relating to the cotton production with the area and yield are depicted in Table 16. All of the regression equations were statistically significant at the 99 percent level of confidence and have a very high explanatory power (adjusted-R^2 ranges from 0.77 to 0.99). The results in Table 16 show that the yield coefficient for the 1970s in the districts of Badin, Hyderabad, Jaccobabad, Khairpur, Larkana, Nawabshah, Sanghar, Sukkur, Tharparkar and Thatta are positive; however, it becomes negative in the districts of Badin, Jaccobabad and Nawabshah during the 1980s. This rate of decrease further intensified in the districts of Badin, Hyderabad, Shikarpur and Tharparkar during the 1990s.

Figure 3 Trends in Area and Production in Cotton in the Sindh Province

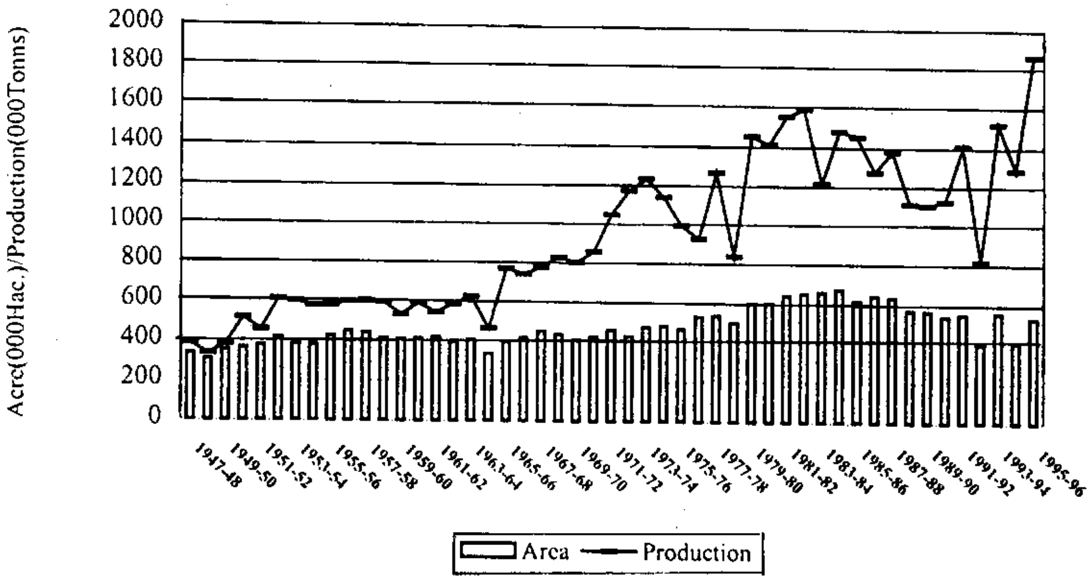


Figure 3(A). Trends in Yields of Cotton in the Sindh Province (1947-1996).

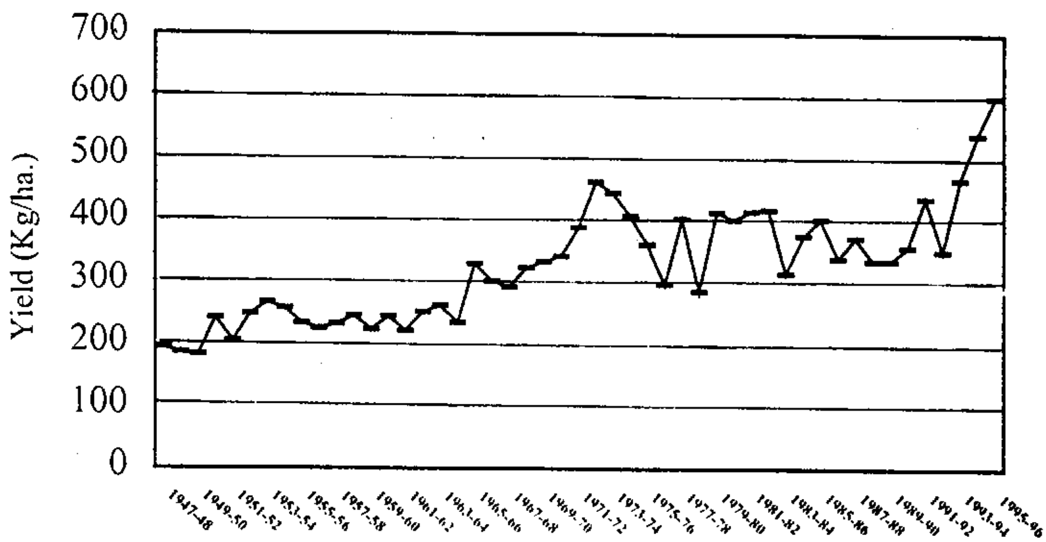
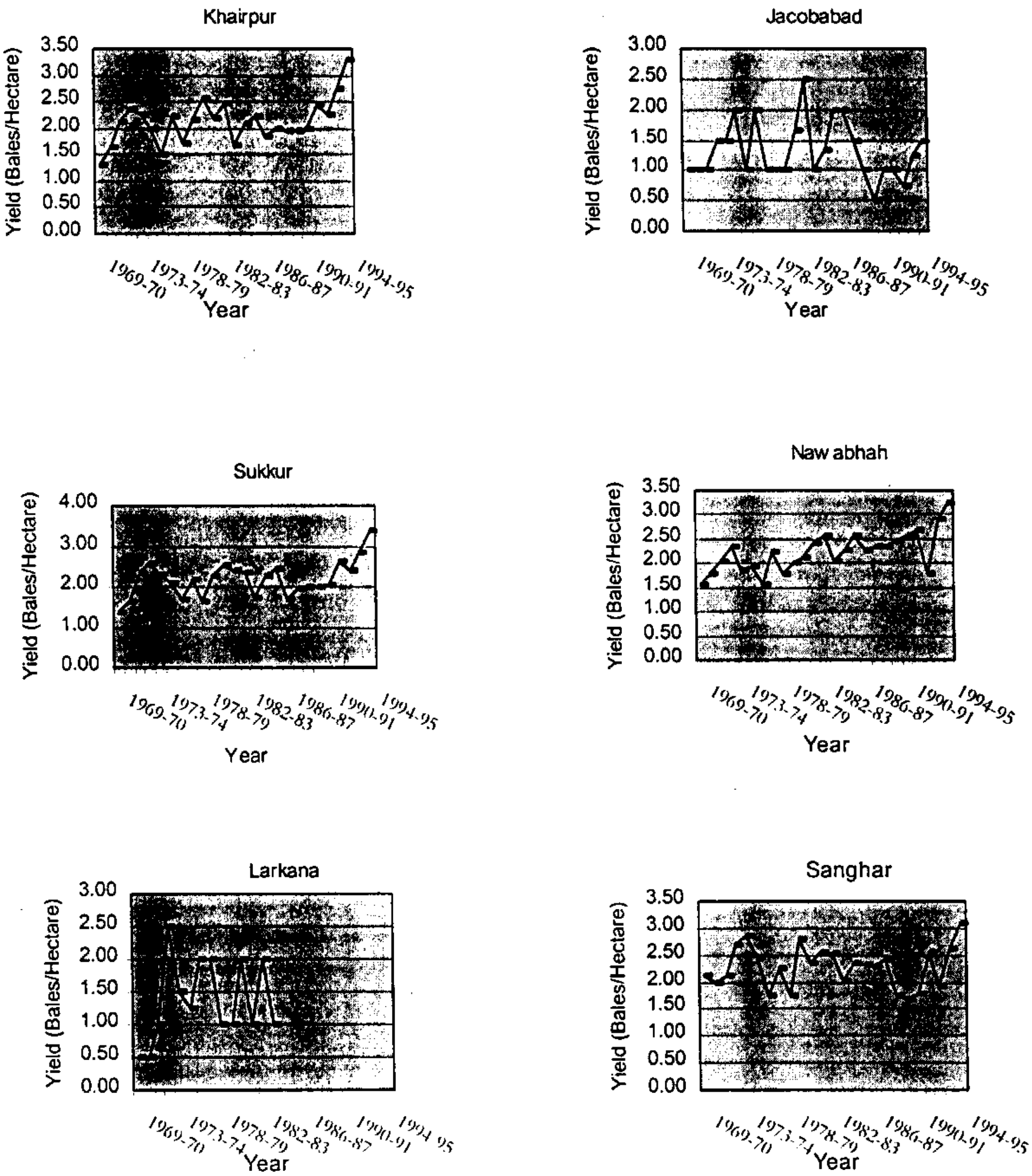
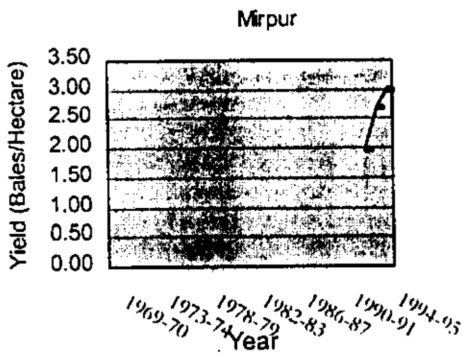
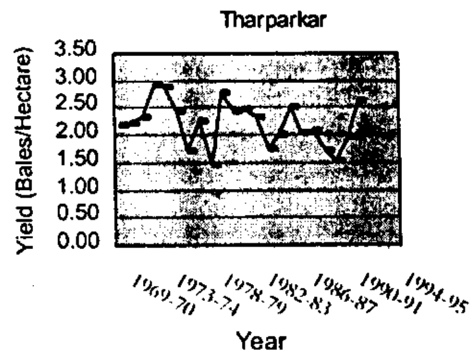
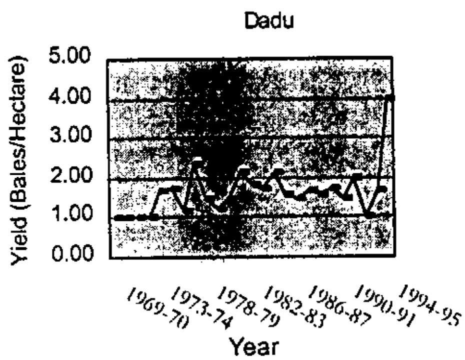


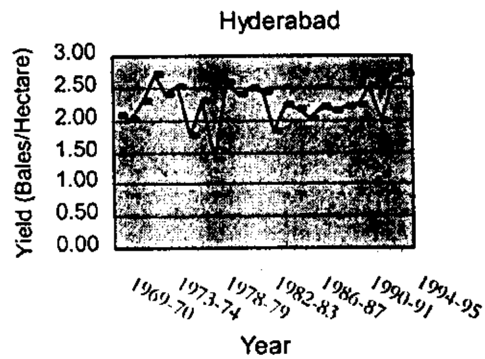
Figure 3(B). District-wise Spatial and Temporal Changes in Yields of Cotton in the Sindh Province.

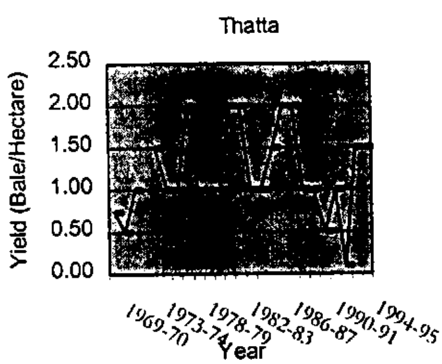


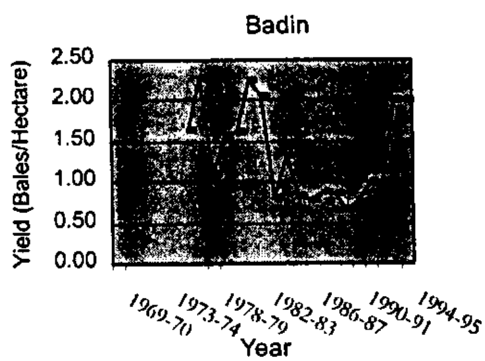

Mirpur
Yield (Bales/Hectare)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year

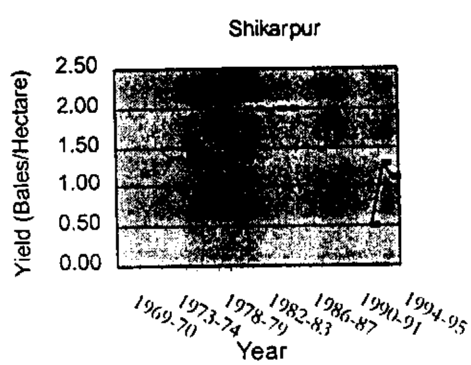

Tharparkar
Yield (Bales/Hectare)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Dadu
Yield (Bales/Hectare)
5.00
4.00
3.00
2.00
1.00
0.00
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Hyderabad
Yield (Bales/Hectare)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Thatta
Yield (Bale/Hectare)
2.50
2.00
1.50
1.00
0.50
0.00
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Badin
Yield (Bales/Hectare)
2.50
2.00
1.50
1.00
0.50
0.00
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Shikarpur
Yield (Bales/Hectare)
2.50
2.00
1.50
1.00
0.50
0.00
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year

The coefficients for the area under the cotton crop among all of the 13 districts of Sindh showed an increasing trend during the 1970s, which was significant at the 99 percent level of confidence. A declining trend in the cotton crop was observed for the districts of Dadu, Khairpur, Sanghar and Sukkur. For the Dadu and Sukkur Districts, the coefficient for the area was significant during the 1980s and showed a further declining trend during the 1990s, with respect to area under cotton crop in the districts of Dadu and Shikarpur.

Table 16. Regression Results Relating the Production of Cotton with Respect to the Temporal and Spatial Changes in the Yield and Area of the Cotton Crop in the Sindh Province.

	Constant	Yield	Area	Yield80	Area80	Yield90	Area90	Ad-R Square	F-calc	DF Total
Badin	-3.04 (1.65)	1.48 (0.01)		-0.01 (0.02)	0.82 (0.32)	-0.12 (0.01)		0.92	72.28	24
Dadu	-1.67 (2.35)		1.74 (0.09)	0.02 (0.01)	-1.04 (0.27)	0.03 (0.01)	-1.30 (0.35)	0.96	101.86	24
Hyderabad	-146.27 (7.92)	0.45 (0.01)	1.93 (0.10)			-0.11 (0.02)	0.59 (0.13)	0.99	792.81	24
Jaccobabad	-.70 (0.14)	0.004 (0.001)	1.18 (0.07)	-0.001 (0.00)				0.94	138.40	24
Khairpur	-111.71 (6.07)	0.30 (0.01)	2.23 (0.12)	0.038 (0.02)	-0.29 (0.13)			0.98	424.61	24
Larkana	-0.04 (0.03)	0.00 (0.00)	0.92 (0.18)					0.77	40.59	24
Mirpur Khas	-0.27 (1.34)					0.15 (0.04)	1.48 (0.29)	0.98	765.00	24
Nawabshah	-197.25 (8.88)	0.56 (0.04)	2.11 (0.09)	-0.09 (0.04)			0.44 (0.17)	0.99	946.17	24
Sanghar	-261.59 (14.40)	0.61 (0.02)	2.54 (0.12)	0.18 (0.07)	-0.54 (0.19)			0.99	680.96	24
Shikarpur	-0.00 (0.00)		2.00 (0.01)			-0.001 (0.000)	-0.36 (0.11)	1	26694. 22	24
Sukkur	-115.84 (15.77)	0.32 (0.04)	2.16 (0.15)	0.12 (0.05)	-0.49 (0.21)	0.20 (0.07)	0.69 (0.30)	0.98	234.79	24
Tharparkar	-12.13 (11.58)	0.63 (0.03)				-0.19 (0.04)		0.94	191.09	24
Thatta	-0.61 (0.11)	0.003 (0.001)	1.18 (0.09)					0.92	139.49	24

3) District-wise Temporal Variation in the Area, Production and Productivity of Rice in the Sindh Province

On the Right Bank of the Indus River in the Sindh Province, the farmers grow the coarse variety of rice (IRRI-6) in the canal commands of Northwest, Rice and the Desert Canals. The trends in the total area, production and yield under the rice crop from 1947-48 to 1995-96 have been shown in Figures 4 (a)-(c). The total area under paddy in the Sindh Province was about 0.642 Mha, which was about 29.71 percent of the paddy area in Pakistan (2.161 Mha). About 1.697 MT of rice has been produced from the Sindh area during 1995-96. The average yield was about 2.64 tons per hectare. From Figure 4(c), the paddy production in all of the districts except Sanghar, Hyderabad, Badin and Thatta increased during the mid-1970s. The main reason for this increase was the introduction of the high-yielding coarse variety IRRI-6. Part of this boost in the per-unit yield was the result of additional irrigation supplies from the Rice Canal and the provision of the subsidized fertilizer and insecticides on the farms during the Green Revolution period. The yield decline beyond the mid-1980s in all of the districts of the Sindh Province was partly due to the reduction of the subsidy on fertilizer as well as insecticides. The districts of Shikarpur, Jaccobabad, Larkana and Dadu are exceptions.

The summary of the regression results, relating the rice production with the area and yield over time, has been given in Table 17. The estimated equations are found statistically significant at the 99 percent level of confidence. The examination of estimated coefficients for yield in the equation for districts in the Sindh Province showed that the per unit paddy yield depicted an increasing trend from the 1970s to 1990s, except for the Badin, Dadu, Jaccobabad and Tharparkar Districts. The coefficients for the yield during the 1980s and 1990s for the remaining districts are statistically significant and showed the positive sign.

The estimated coefficients for the area in all of the 13 districts have positive coefficients that are statistically significant at the 99 percent level of confidence, showing that during the 1970s the area had a positive relationship with the production of rice in the Sindh Province. During the 1980s the coefficients for area in the districts of Badin, Nawabshah and Shikarpur showed a declining trend in the area under the cultivation of rice. The Districts of Badin, Larkana, Nawabshah, Sanghar and Shikarpur showed a negative trend during the 1990s.

Figure 4. Trends in Area and Production of Rice in the Sindh Province.

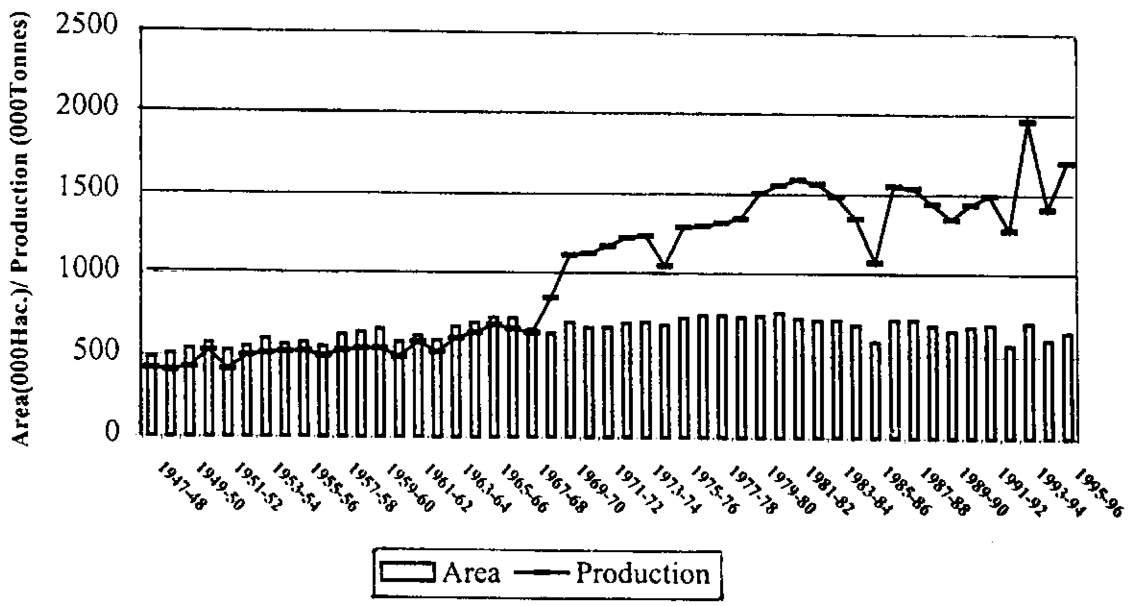


Figure 4 (A). Trends in Yields of Rice in the Sindh Province.

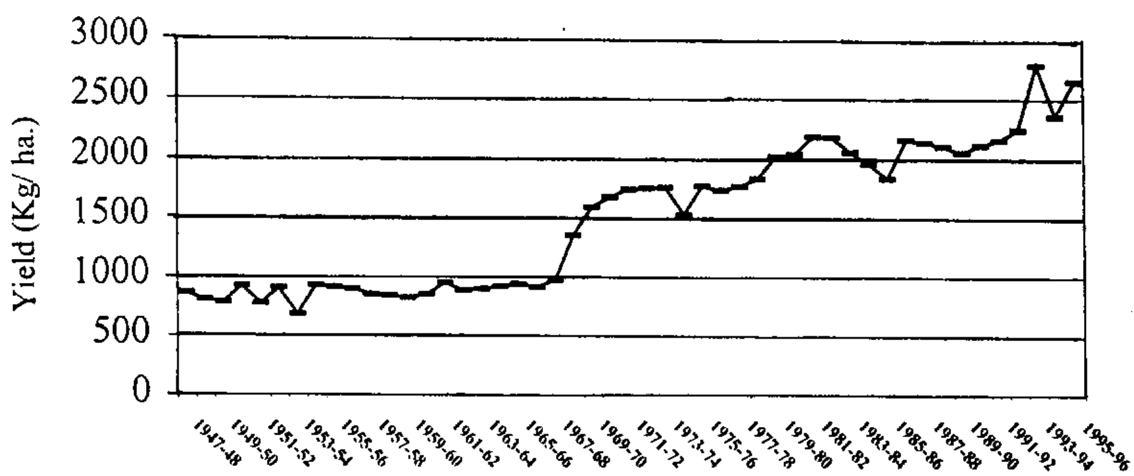
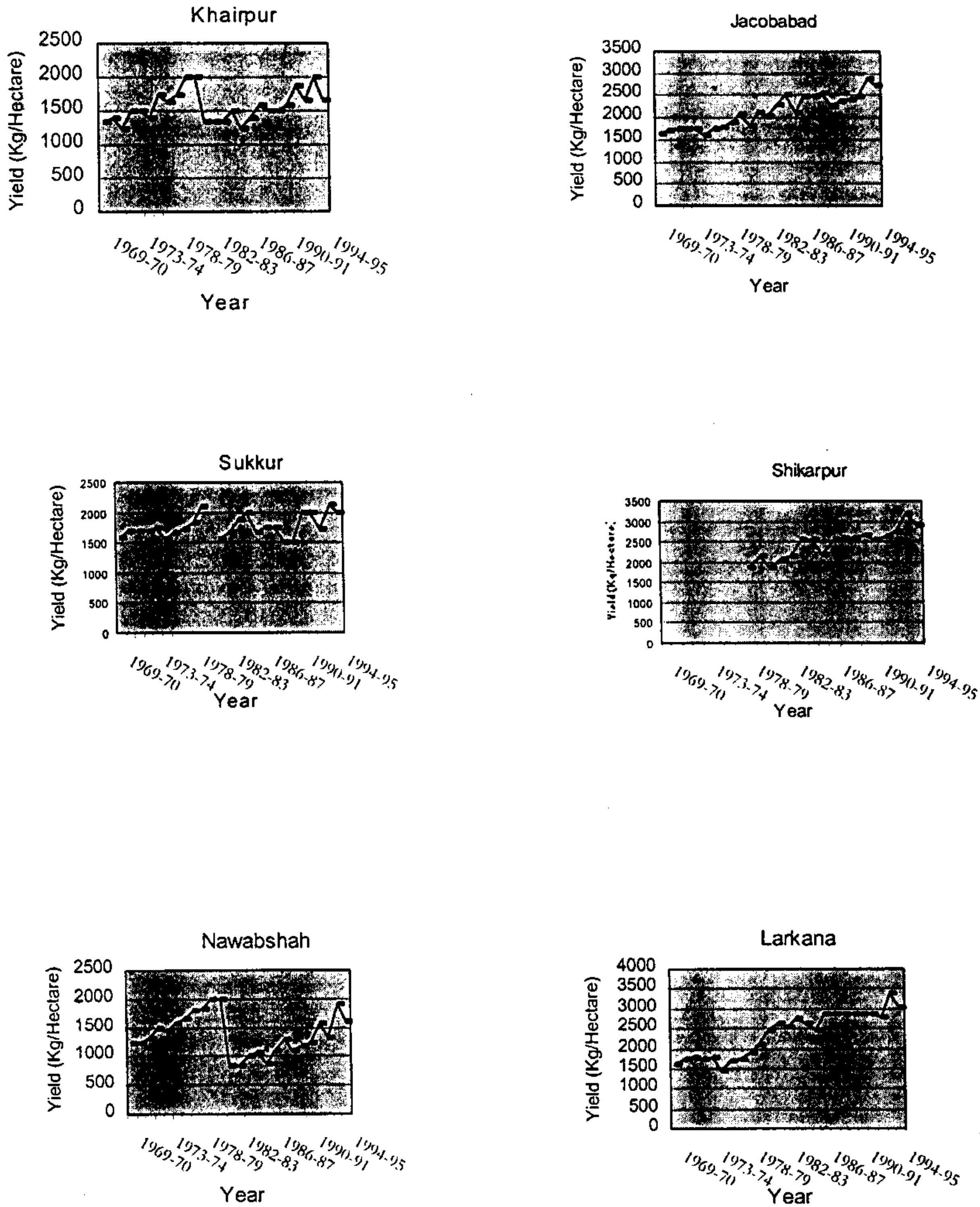
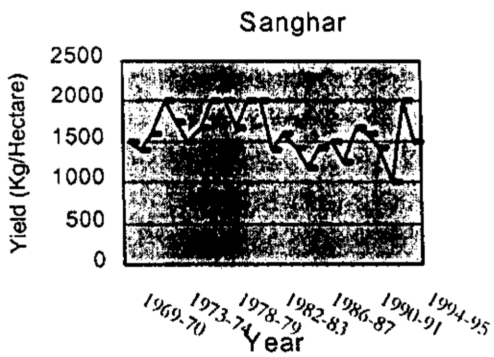
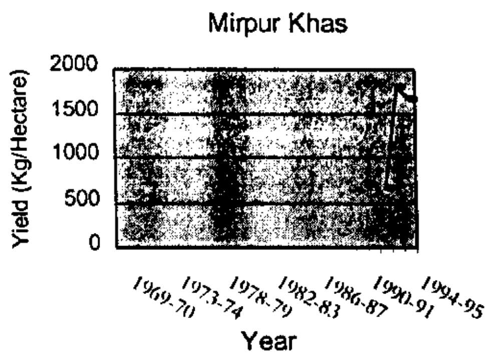
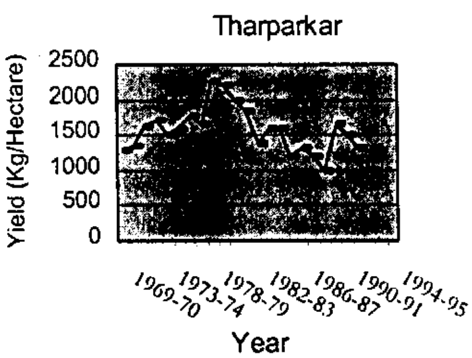


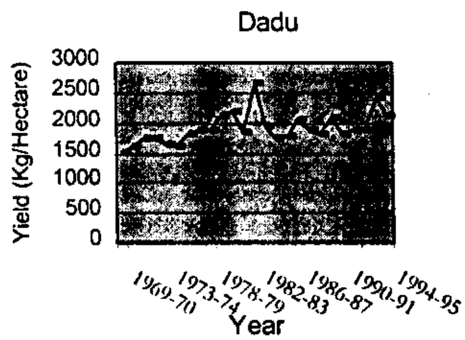
Figure 4(B). District-wise Spatial and Temporal Changes in Yields of Rice in the Sindh Province.

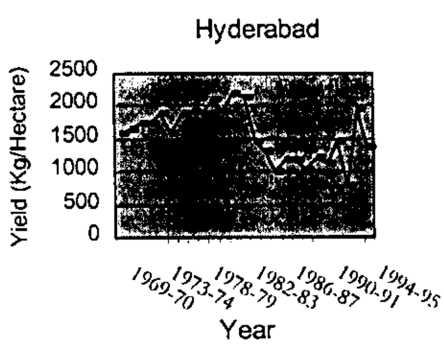


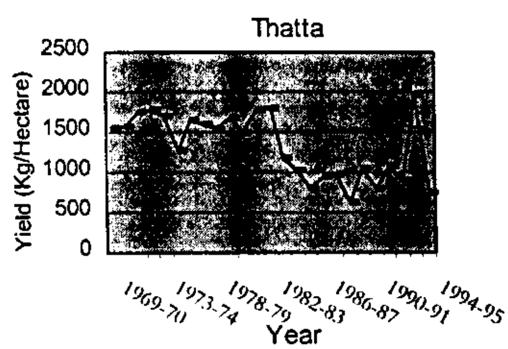

Sanghar
Yield (Kg/Hectare)
2500
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Mirpur Khas
Yield (Kg/Hectare)
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Tharparkar
Yield (Kg/Hectare)
2500
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Dadu
Yield (Kg/Hectare)
3000
2500
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Hyderabad
Yield (Kg/Hectare)
2500
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Thatta
Yield (Kg/Hectare)
2500
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year

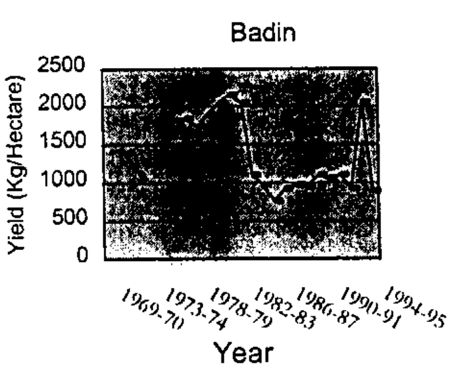

Badin
Yield (Kg/Hectare)
2500
2000
1500
1000
500
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year

Table. 17. Regression Results Relating the Production of Rice with Respect to the Temporal and Spatial Changes in the Yield and Area of the Rice Crop in the Sindh Province.

	Constant	Yield	Area	Yield80	Area80	Yield90	Area90	AdR Square	F. calc	DF Total
Badin	-2.10	0.12			-0.29	-0.04		0.97	281.11	24
	(5.23)	(0.004)			(0.07)	(0.01)				
Dadu	-112.35	0.06	1.77	-0.007	0.24	-0.006	0.19	0.99	1163.93	24
	(2.92)	(0.002)	(0.04)	(0.002)	(0.05)	(0.002)	(0.07)			
Hyderabad	-35.65	0.02	1.67					0.99	1889.73	24
	(4.50)	(0.003)	(0.03)							
Jaccobabad	-324.13	0.17	1.96	-0.02	0.24	-0.04	0.70	0.99	751.97	24
	(11.96)	(0.01)	(0.12)	(0.01)	(0.11)	(0.01)	(0.15)			
Khairpur	-5.77	0.003	1.57				0.14	0.98	402.72	24
	(0.88)	(0.001)	(0.06)				(0.05)			
Larkana	-408.05	0.14	2.92			0.06	-0.93	0.99	2606.49	24
	(14.33)	(0.01)	(0.20)			(0.02)	(0.31)			
Mirpur Khas	-0.04					0.002	0.59	0.94	196.35	24
	(0.10)					(0.001)	(0.27)			
Nawabshah	-9.17	0.005	1.61		-0.23	0.004	-0.67	0.96	148.71	24
	(1.12)	(0.001)	(0.09)		(0.06)	(0.002)	(0.25)			
Sanghar	-5.86	0.003	1.51			0.001	-0.27	0.98	316.71	24
	(0.50)	(0.000)	(0.05)			(0.000)	(0.12)			
Shikarpur	-1.57		2.05	0.07	-1.55	0.14	-3.41	0.98	430.35	24
	(4.01)		(0.11)	(0.01)	(0.36)	(0.04)	(1.14)			
Sukkur	1.11		1.66					0.99	10308.58	24
	(0.91)		(0.02)							
Tharparkar	-1.75	0.001	1.54	-0.003				0.95	255.08	24
	(0.89)	(0.001)	(0.08)	(0.002)						
Thatta	-83.24	0.08	1.12			-0.02	0.43	0.99	768.42	24
	(4.97)	(0.004)	(0.08)			(0.006)	(0.13)			

4) District-wise Temporal Variation in the Area, Production and Productivity of Sugarcane in the Sindh Province

Sugarcane is grown in almost all districts of Sindh on the Left Bank of the Indus River, but its area or acreage varies from district to district. For example, it is grown most abundantly in District Badin and on a large scale in Districts Hyderabad, Nawabshah, Mirpurkhas and Naushehro Feroze. The average yield of sugarcane, as communicated by the respondents, is about 69 tons/ha. The yield depends upon soil, irrigation, diseases, climate, etc. The area of sugarcane also fluctuates because of a marketing problem and prices. The acreage under the sugarcane crop in the Sindh Province has expanded from 0.007 Mha during 1947-48 to about 0.254 Mha during 1995-96 [(Figure 5(a)]

Figure 5. District-wise Temporal Changes in Area and Production of Sugarcane in the Sindh Province.

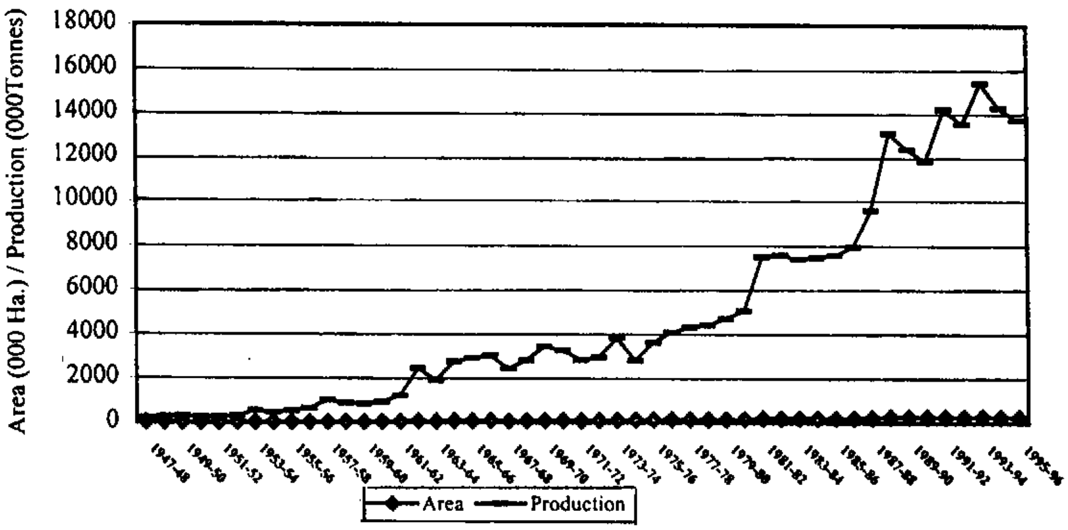


Figure 5(A). District-wise Temporal Changes in Yields of Sugarcane the Sindh Province.

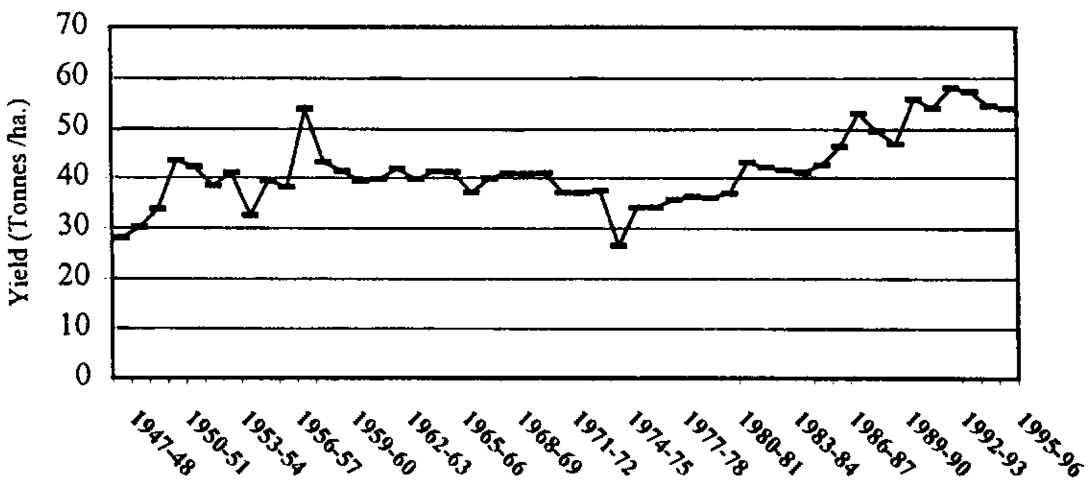
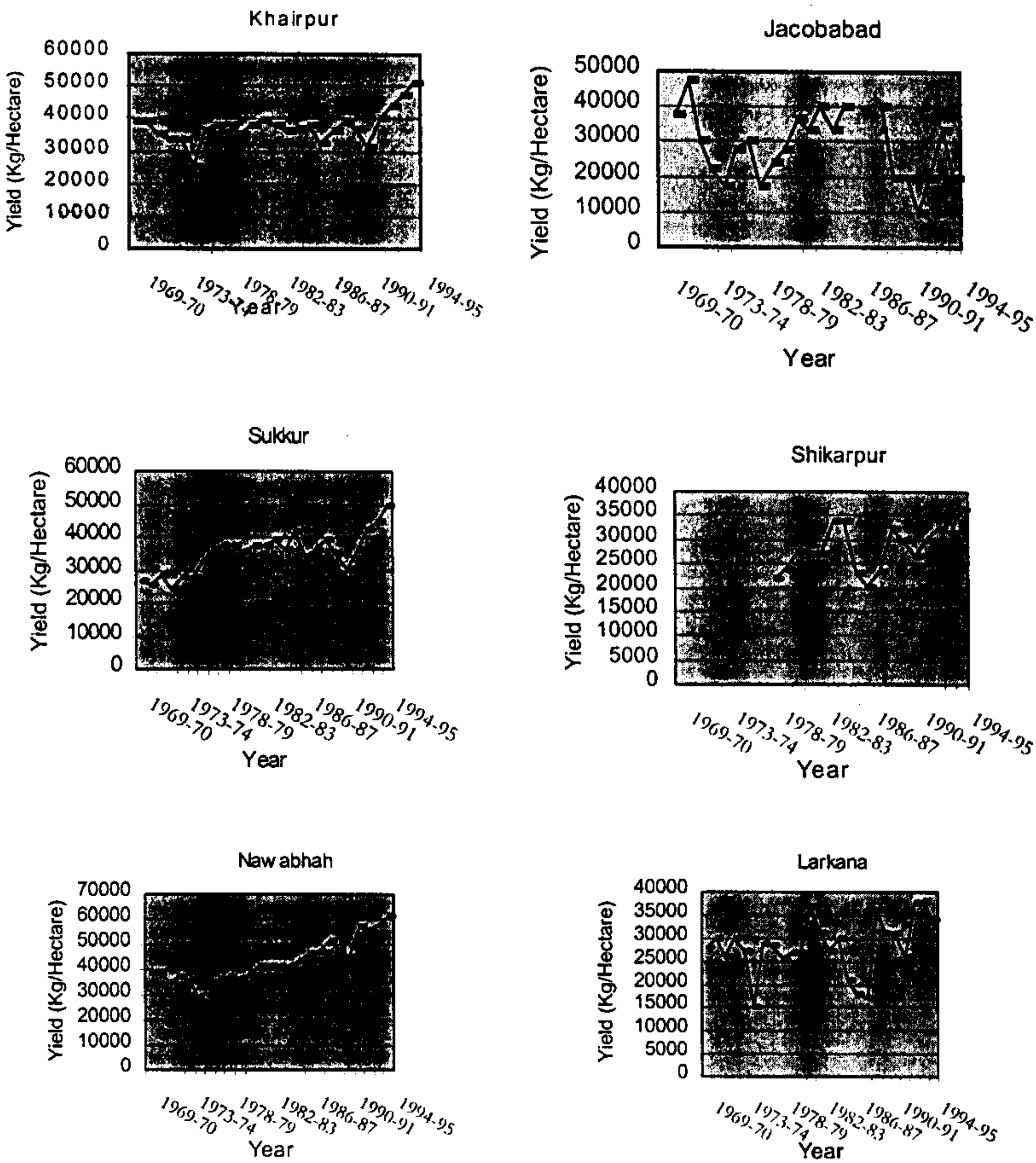
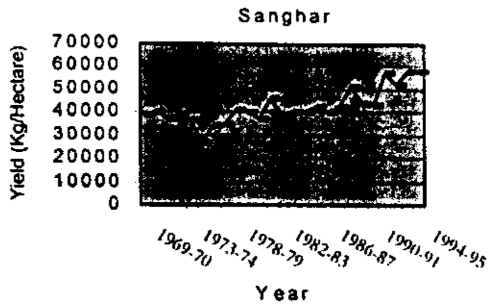
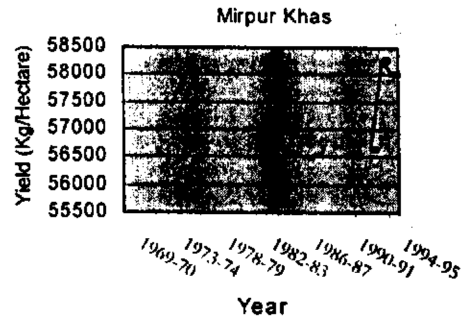
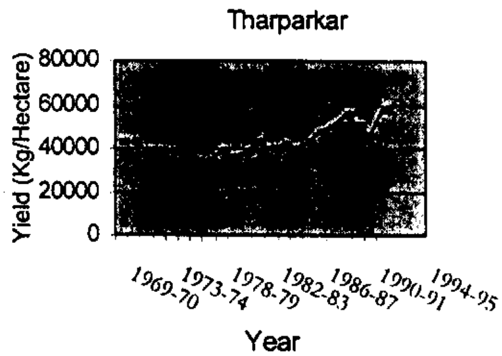


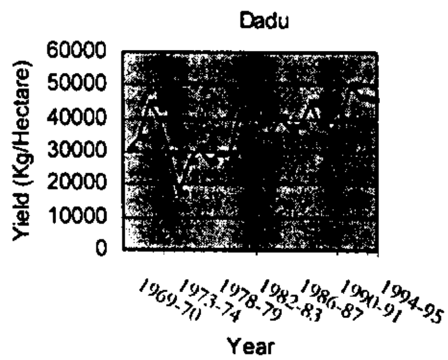
Figure 5(B). District-wise Spatial and Temporal Changes in Yields of Sugarcane in the Sindh Province.

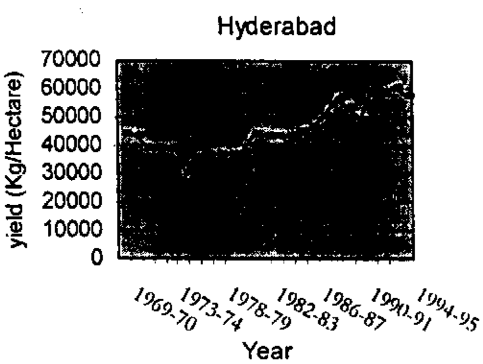


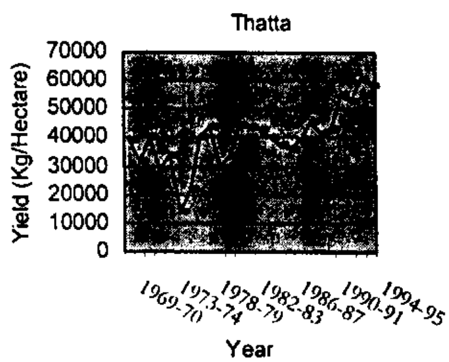

Sanghar
Yield (Kg/Hectare)
70000
60000
50000
40000
30000
20000
10000
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Mirpur Khas
Yield (Kg/Hectare)
58500
58000
57500
57000
56500
56000
55500
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Tharparkar
Yield (Kg/Hectare)
80000
60000
40000
20000
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Dadu
Yield (Kg/Hectare)
60000
50000
40000
30000
20000
10000
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Hyderabad
yield (Kg/Hectare)
70000
60000
50000
40000
30000
20000
10000
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year


Thatta
Yield (Kg/Hectare)
70000
60000
50000
40000
30000
20000
10000
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year

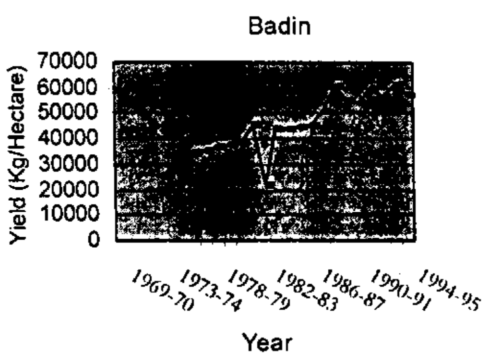

Badin
Yield (Kg/Hectare)
70000
60000
50000
40000
30000
20000
10000
0
1969-70
1973-74
1978-79
1982-83
1986-87
1990-91
1994-95
Year

Table 18. Regression Results Relating the Production of Sugarcane with Respect to the Temporal and Spatial Changes in the Yield and Area of the Sugarcane Crop in the Sindh Province.

	Constant	Yield	Area	Yield80	Area80	Yield90	Area90	AdR Square	Fcalc	DF Total
Badin	-91.13	0.04			12.98		22.54	0.97	259.28	24
	(83.92)	(0.003)			(3.15)		(3.41)			
Dadu	-93.62	0.002	33.27	0.0005		0.0004		0.97	251.66	24
	(18.31)	(0.000)	(2.31)	(0.000)		(0.000)				
Hyderabad	-1495.26	0.04	34.59	-0.017	22.92	0.01		0.99	1932.74	24
	(175.84)	(0.004)	(1.99)	(0.003)	(4.19)	(0.002)				
Jaccobabad	-0.35	0.0002	11.43	-0.0002	16.71	-0.0002		0.96	124.08	24
	(0.57)	(0.000)	(1.43)	(0.000)	(3.06)	(0.000)				
Khairpur	-264.31	0.007	37.02	0.006			-18.47	0.99	2677.59	24
	(20.52)	(0.001)	(0.51)	(0.001)			(2.36)			
Larkana	-40.74	0.001	28.08		2.30			0.98	597.35	24
	(4.07)	(0.000)	(0.71)		(0.79)					
Mirpur Khas	-0.04						57.65	1.00	132756.5	24
	(1.39)						(0.16)			
Nawabshah	-1159.31	0.029	40.66	-0.0001	13.89	0.01	-8.15	0.99	1707.55	24
	(116.79)	(0.003)	(2.99)	(0.004)	(5.50)	(0.003)	(3.74)			
Sanghar	-300.22	0.007	43.80			0.004	-16.51	0.99	2154.40	24
	(15.50)	(0.000)	(1.26)			(0.001)	(3.73)			
Shikarpur	-0.55	0.0005		-0.0004	27.28	-0.0001		0.95	135.41	24
	(0.77)	(0.000)		(0.0001)	(2.16)	(0.000)				
Sukkur	-236.95	0.01	15.55	-0.003	21.38	0.002		0.99	485.74	24
	(21.91)	(0.000)	(6.95)	(0.001)	(7.94)	(0.001)				
Tharparkar	-25.14	-0.006	67.94			0.035	-78.14	0.98	407.39	24
	(25.81)	(0.001)	(3.51)			(0.007)	(15.43)			
Thatta	-141.14	0.003	40.74			0.04	-94.39	0.98	548.13	24
	(53.63)	(0.002)	(1.79)			(0.01)	(30.45)			

The yield of sugarcane has increased more profoundly than any other crop in Sindh. Its yield was 34 tons in 1974-75, and has increased more or less continuously since 1975. The average yield in 1994-95 was 57.3 tons per ha. This increase in the yield could be due to good climatic conditions, better management, high yielding varieties and more input. Since fertilizer consumption has also increased considerably, so this may have a positive effect on its yield. Figure 5(b) shows the production of the sugarcane crop in the 13 districts of the Sindh Province.

From Table 18 all of the regression equations, depicting trends in the sugarcane production with respect to the area and productivity, are statistically significant at the 99 percent level of confidence. The overall explanatory power is very high (the adjusted R^2 ranges from 0.95-0.99). For all the districts of the Sindh Province that grow sugarcane, the results show an increasing trend in the sugarcane area that is offset by a declining trend in the area during the 1990s in the District of Khairpur. Regarding the productivity of sugarcane, except for Districts Hyderabad, Jaccobabad, Shikarpur and Sukkur, all the coefficients for the yield during the 1980s are positive and statistically significant at the 99 percent level of confidence. The coefficients show that the sugarcane yield further declines during the 1990s in the Districts of Jaccobabad and Shikarpur.

V CURRENT STATUS OF INPUT USE IN THE SINDH PROVINCE

1) Irrigation Water

Water is of vital importance in agricultural production. In most parts of the Sindh Province, groundwater contains high salt concentrations. The main source of irrigation for agriculture is canals. In 1975-76, out of the total of 3.18 million hectares of irrigated agricultural land, 2.66 million hectares were irrigated with canal water. This is 83.6 percent of all the sources. Also, 0.06 million hectares were irrigated with canal water. These figures show the importance of canal water in agricultural production. According to data of 1994-95 (Agriculture Statistics of Pakistan 1995-96) about 94.7 percent of agricultural area was irrigated by surface water, and the remainder with groundwater.

Table 19 reveals that about 87 percent of the farms in the study area prefer to use canal water as a source of irrigation. Only 0.8 percent of farms depend upon tubewell water and about 12 percent of farms supplement the canal water supply with tubewell water.

Table 19: Source of Irrigation Water on Farms in different Canal Commands of the Sindh. Provine (1997-98).

Canal Commands	Source of irrigation water							
	Farms using canal water		Farms using tubewell water		Farms using canal & tubewell water		Total	Total Number
	Number	%	Number	%	Number	%	%	of farms
Begari	124	75			42	25	100	166
Dadu	27	87			4	13	100	31
Desert	39	64			22	36	100	61
Fuleli	74	100					100	74
Ghotki	127	68	5	3	54	29	100	186
Jamrao	127	99			1	1	100	128
Khairpur East	76	96			3	4	100	79
Khairpur West	56	86	5	8	4	6	100	65
Lined Channel	56	100					100	56
Nara	105	100					100	105
North West	186	96			7	4	100	193
Pinyari	25	100					100	25
Rice Canal	98	95			5	5	100	103
Rohri	218	82	2	1	47	18	100	267
Sindh	1338	87	12	1	189	12	100	1539

The survey revealed that farmers in Sindh depend mostly on the canal water supply due to three reasons. They perceived that (i) canal water is of better quality than available groundwater, (ii) canal water moves due to the gravitational force and the farmers do not have to pump it out, (iii) groundwater is more expensive than surface water.

With respect to the spatial distribution of farms, Table 19 shows that about 25 percent in the Begari, 13 percent in Dadu, 36 percent in Desert, 29 percent in Ghotki and about 18 percent in the Rohri Canal commands use canal and tubewell water. In the Khairpur West, Khairpur East, Rice, Dadu and Desert Canal commands, this percentage of farms ranges between 1 to 13 percent. This conjunctive use of water is because these canal commands have some areas of groundwater that are less saline. According to WAPDA, the culturable command areas of the Nara, Lined Channel, Fuleli and Pinyari Canals have totally saline groundwater. Therefore, none of the respondents in these canal commands irrigate their fields with tubewell water, except in the Khairpur East Canal command where only three farmers were irrigating with tubewell water mixed with the canal water.

The farm survey in Sindh, where a considerable area is waterlogged and has a drainage problem, revealed that farmers still demand more water for irrigation. During the irrigation of their crops they do not take crop water requirements and the presence of moisture in the soil into account. They irrigate because they think it is good to irrigate. A common notion in the area of shallow groundwater is that heavy irrigation restricts groundwater from approaching the surface. In this way, the farmers try to reduce salinity but aggravate waterlogging and drainage problems.

Table 20: Farmers' Responses about the Adequacy of Canal Water Supplies in the Sindh Province (1997-98)

Response about canal water supply	Farms reporting	
	Number	Percent
Farmers reporting shortage of water	942	61.2
Farmers reporting sufficient water	597	38.8
Total	1539	100.0

Table 20 shows that about 39 percent of farmers are satisfied with the current water supply. Also, about 61 percent of the sample farmers reported shortages of irrigation supplies on their farms with the current water supply. Among other reasons, the most common was that they receive less water than allocated. The time allocated per unit of area is less than the time required for filling it. The survey results revealed that almost 58 percent of the farmers do not know the exact time allocated for irrigation. They irrigate their fields whenever they need. They do not apply the warabandi system followed in the Punjab Province. All of the farmers open their nakas simultaneously to irrigate their fields. Most of the times, tail-enders are the main sufferers. The second reason for the lack of knowledge about the time allocated is that some large farmers have their own watercourses to irrigate their fields. All the time of that watercourse is allocated to one farm. The tenants of the same landlord get water from the same watercourse devoid of proportion and time, and they were unable to give any estimates about the time allocation for their turn of water.

Table 21. Farmers' Responses about the Time Allocated per Unit of Area in the Sindh Province (1997-98).

Time allocated to irrigate one hectare	Banks of the Indus River				Table Total	
	Right Bank		Left Bank			
	Number	%	Number	%	Number	%
Unknown	509	91.9	392	39.8	901	58.5
37 Minutes	29	5.2	239	24.3	268	17.4
38-75 Minutes	6	1.1	213	21.6	219	14.2
76-112 Minutes	1	0.2	56	5.7	57	3.7
113-150 Minutes	2	0.4	46	4.7	48	3.1
Above 150 Minutes	7	1.3	39	4.0	46	3.0
All Farms	554	100.0	985	100.0	1539	100.0

From Table 22 it is evident that this practice is more common on the Right Bank of the Indus River, especially in the Begari, Dadu and Rice Canals. Farmers reported having enough water in the Kharif and Rabi seasons. They use the same moisture for wheat and sarsoon because soils in these regions are fine-textured and can retain moisture for comparatively longer periods. The excess soil moisture (at the harvest of the rice crop) is also reported to be a problem for wheat-sowing as soils do not come to the field capacity level for wheat-sowing, and usually delays the wheat-sowing on the Right Bank of the Indus River. As far as the time required to fill one hectare is concerned, about 64 percent of the farmers fill one hectare in less than two-and-a-half hours.

Table 22. Farmers' Responses about the Time Required to Irrigate One Hectare of Land in the Sindh Province (1997-98).

Time required to fill one hectare	Banks of the Indus River				Total	
	Right Bank		Left Bank			
	Number	%	Number	%	Number	%
No Response	52	9.4	37	3.8	89	5.8
37 Minutes	5	0.9	5	0.5	10	0.6
38-75 Minutes	33	6.0	69	7.0	102	6.6
76-112 Minutes	6	1.1	38	3.9	44	2.9
113-150 Minutes	92	16.6	219	22.2	311	20.2
Above 150 Minutes	366	66.1	617	62.6	983	63.9
All Farms	554	100.0	985	100.0	1539	100.0

Whatever the time allocated to fill one hectare, the time required to fill one hectare might not be the same. This time depends upon the discharge of the watercourse and its physical conditions. Farms at the head and middle reaches use water in excess, but at the tail end farmers suffer from water shortages. The third reason for the shortage of water on the farms in the Sindh Province was that farm elevations were higher than the watercourses. In such areas, farmers reported that they were required to pump water from the watercourse to fields. Some farmers on the Left Bank use diesel/ electric pumps to lift water, but on Right Bank, farmers block the watercourse at their fields to raise the surface of the water and then lead water to their fields.

Table 23. Farms using Lift Pumps to Irrigate their Fields in the Sindh Province (1997-98).

Lift machine to irrigate fields	Banks of the Indus River				Table Total	
	Right Bank		Left Bank			
	Number	%	Number	%	Number	%
Lift not Used	538	97.1	884	89.7	1422	92.4
Lift Used	16	2.9	101	10.3	117	7.6
All Farms	554	100.0	985	100.0	1539	100.0

Table 23 shows that out of the total sample, about 7.6 percent of farms reported using lift pumps to irrigate their fields, out of which 16 farms are located on the Right Bank of the Indus River and about 117 farms on the Left Bank. Lifting irrigation water increases the cost of irrigation and reduces the profitability of crops. So, in those regions where water has to be lifted, farmers avoid high delta crops. The reasons for the low water supply are also depicted in Table 24.

Table 24. Reasons for the Shortage of Water in the Sindh Province (1997-98).

Reasons for the shortage of water	Number of farms	Percentage
Unknown	70	7.4
Small Size of Mogha	85	9.0
Conveyance Losses	93	9.9
Breaches	179	19.0
Low Discharge	352	37.4
Tail Reaches	107	11.4
High Elevation of Field	12	1.3
Others	44	4.7
Total	942	100

About 37 percent of the farmers stated that the problem of water shortage is due to the lower discharge in the distributary. The major reason for not using groundwater is its quality. As stated earlier, out of about 5,098 thousand hectares of culturable command area, only 475.91 thousand hectares has usable groundwater and the remaining area (2,696.92 thousand hectares) is a saline zone. In saline zones, farmers do not install tubewells for irrigation. Even in the fresh water zone they do not use tubewell water up to its potential. Only a small number of farmers reported having tubewells installed on their farms. Small farmers reported that they were unable to afford the high cost for tubewell installation and large farmers reported not having the problem of irrigation water scarcity. The medium-sized farmers were of the opinion that the government is responsible for installing tubewells for farmers.

2) Farmers' Perceptions about Groundwater Quality

As far as the quality of the groundwater is concerned, the results of this study are based on the data collected from the farms during the survey. Acquiring data about the groundwater quality was difficult because farmers in the saline zone have never irrigated their fields with groundwater, and in the fresh zone farmers determine the water quality to about 30 to 50 feet as they have made bores for their hand pumps at this depth. However, some farmers explained that the groundwater quality is good because they had tubewells for vertical drainage in their vicinity.

Table 25. Farmers' Perceptions of the Groundwater Quality in the Sindh Province (1997-98).

Canal Command	Groundwater Quality						Total	
	Good		Marginal		Brackish			
	Number	%	Number	%	Number	%	Number	%
Begari	104	62.7	5	3.0	57	34.3	166	100
Dadu	23	74.2			8	25.8	31	100
Desert	38	62.3	2	3.3	21	34.4	61	100
Fuleli	8	10.8	4	5.4	62	83.8	74	100
Ghotki	151	81.2	3	1.6	32	17.2	186	100
Jamrao	10	7.8	8	6.3	110	85.9	128	100
Khairpur (E)	39	49.4	3	3.8	37	46.8	79	100
Khairpur (W)	55	84.6			10	15.4	65	100
Lined Channel	11	19.6	8	14.3	37	66.1	56	100
Nara	12	11.4	7	6.7	86	81.9	105	100
North West	57	29.5	9	4.7	127	65.8	193	100
Pinyari	5	20.0	6	24.0	14	56.0	25	100
Rice Canal	64	62.1	2	1.9	37	35.9	103	100
Rohri	137	51.3	21	7.9	109	40.8	267	100
Sindh	714	46.4	78	5.1	747	48.5	1539	100

Table 25 shows that the farm respondents stated the highest percentage of brackish water in the Fuleli, Nara, Jamrao, and the Lined Channel Canals. The highest percentage of good quality groundwater in the Khairpur-West and Ghotki Canals indicate the presence of a fresh groundwater zone in these canal commands. In the Rohri Canal, about 50 percent of the respondents reported the occurrence of sweet water on the sample farms. One reason for the preference of surface water is that the groundwater is more expensive than surface water. Groundwater has a dual effect on the profitability of crops. First, it increases the cost of the production of crops by increasing the cost on irrigation, and secondly, it reduces the yield of crops by increasing the salt deposition in the field (if groundwater is of bad quality). That is why farmers avoid groundwater. Table 26 depicts the comparison of costs of irrigation canal water and tubewell water used on the sample farms in canal commands of the Sindh Province.

unable to absorb excess moisture. Farmers do not manage excess moisture and do not have on farm drainage system. Therefore, a heavy rainfall may create this problem. Farms that have lower elevations than other farms reported the drainage problem more acutely due to their topographic conditions. Water from other farms, or their own farm is collected on these fields, which oftentimes, is reported to destroy the crops planted in these fields. Over-irrigation was commonly practiced, but farmers did not think this contributed to their problem.

Table 31. Farmers' Perceptions about Reasons for Drainage Problems in Different Canal Commands of the Sindh Province (1997-98).

Canal Commands	Reasons (percentage distribution of farms reporting a drainage problem)								Farms Reporting Problems	Total Farms
	Unknown	High Watertable	Rainfall	Topography	Over Irrigation	Soil Condition	No Drains	Others		
Begari		80	3	3		1	13		148	166
Dadu		46		19		4	31		26	31
Desert		84		6			10		50	61
Fuleli	8	75	4	2	2		10		51	74
Ghotki		45	6	18		1	30		152	186
Jamrao	5	34	5	8	1	1	42	4	83	128
Khairpur East		54		13			33		54	79
Khairpur West		53	2	6		2	36	2	53	65
Lined Channel	4	36				2	40	18	45	56
Nara		14	5	24			56	2	59	105
North West	2	49	7	15	1	3	23		146	193
Pinyari		80		15			5		20	25
Rice	2	16	7	48			25	2	56	103
Rohri	2	43	3	15		3	34	1	154	267
Overall	2	50	4	13	0	1	28	1	1097	1539

Table 31 shows that overall, about 50 percent of the farm respondents perceived that the drainage problem persisted due to a high watertable, and the second major reason stated by about 28 percent of the farmers, is the lack of access to the drainage system. Some farmers reported that they tried to solve the drainage problem by pumping out excess water into the nearby watercourse or to sow rice on waterlogged soils. Table 32 displays the farmers' responses on how they tackle this problem.

5) Farmers' Solutions to the Drainage Problem in Sindh

Table 32 shows that the percentage of farmers who do not do anything is the highest (29-92 percent) in almost all of the canal commands. Because the problem encompassed a collective area attempts to deal with the problem cannot be tackled by only a few farmers. The survey results revealed that farmers place this responsibility with the government. Overall, about 11 percent of the farmers responded that they want to adopt certain measures, but were prevented by the lack of resources or cooperation from the other farmers. Table 32 also shows their social behavior; about 6 percent of the farmers tried to construct private drains, but neighboring farmers did not cooperate. They were not even willing to allow these farmers to expel drainage water into the drainage system. Among other solutions, farmers reported that they reduce the number of irrigation turns to the crop in order to avoid ponding conditions in the field. Others sow rice or other crops that are tolerant to waterlogged conditions.

Table 32. Farmers' Responses towards Solutions of the Drainage Problem in the Sindh Province (1997-98).

Canal Commands	Perceived solutions to the drainage problem*							Farms reporting problem	Total Farms
	0	1	2	3	4	5	6		
Begari	1	94	3	1			2	148	166
Dadu		81	12	4		4		26	31
Desert		84	8			6	2	50	61
Fuleli	6	29	51	2	2		10	51	74
Ghotki		91		1		5	3	152	186
Jamrao	4	43	20	1		13	18	83	128
Khairpur East	4	91		4			2	54	79
Khairpur West		92					8	53	65
Lined Channel	4	53	18			16	9	45	56
Nara		46	10			14	31	59	105
North West	2	77	10			6	5	146	193
Pinyari	5	45	20			15	15	20	25
Rice	4	80	11			2	4	56	103
Rohri	3	57	14	2		7	18	154	267
Sindh	2	72	10	1	0	6	9	1097	1539

Note: *

0. No response **1.** Do not do anything **2.** Do not have resources
3. Less irrigation **4.** Change cropping pattern **5.** Construct a drain on the farm
6. Others

6) Tenurial System in Sindh

Land tenure is concerned with the rights/arrangement under which the land is operated (Census of Agriculture, 1990). Basically, there are three categories of farmers with respect to tenure. These are owners, owner-cum-tenants and tenants. Owner-farms are where the entire land is owned by the operator, tenant farms are where the entire area is taken from other households against a fixed rate in cash/kind, or a share in the produce. Owner-cum-tenant farms are defined as the farms in which a part of an area is owned by the operator's household and the remainder rented from other household(s) for cash or a share of the produce. On the bases of the Sindh survey, these categories may be subdivided into seven classes on the bases of authorities on decision making about what to produce, how much to produce, how to produce and the involvement in farm operations.

A description of these seven categories is given below.

a). Absentee Landlords

These farmers do not cultivate their land themselves. Most prefer to live in urban areas and remain absent from their native villages. They employ managers who take care of the land / interests in their absence. Land is distributed to tenants on different terms and conditions. These tenants perform all of the farm operations and share inputs and the output.

b). Owner-Manager

The majority of owner-managers is also large farmers who do not cultivate their fields themselves. They have no direct involvement in farm operations. They also rent their land to tenants and manage the accounts, inputs and outputs of the farm. The involvement in farm operations is limited to management and supervision.

c). Owner Cultivator

Owner-cultivators not only own their own land, but also cultivate their land themselves. They perform all farm operations on the farm. An owner cultivator is not only a manager, but a laborer too.

d). Owner-Cum-Tenant

Owner-cum-Tenants (OCT) are farmers who have their own land and hire additional land either on fixed rent or a percentage of the output. OCT is fully involved in farm operations, but decision making is limited to his own plot of land.

e). Tenants

Tenants do not own land, they cultivate land rented from other farmers and share the input and output with the owner. Terms and conditions of sharing vary from farm to farm and region to region. Terms and conditions are in favor of the owner or tenant, depending upon the availability of the tenant, the behavior of the landlord and the status of the tenant. Availability of tenants is when other people are willing to cultivate their land. For example some Hindu castes residing on the Left Bank of the Indus River work as tenants on the farms. But, on the Right Bank this type of labor is not available. On the bases of terms and conditions, there are two types of tenants; those who receive 50 percent of the output and those who receive 25 percent of the output. The table indicates the tenants' share in input.

Table 33 shows that the tenant, who shares 25 percent of the produce, shares 25 percent of all inputs and 50 percent or 25 percent of land preparations. These tenants do not take much interest in farming. Due to their weak financial positions they use less input and prepare the land unsatisfactorily. Another reason why they use less inputs is because they purchase these inputs mostly on a credit basis; thus, to avoid heavy interests they confine themselves to minimal input use. One tenant usually gets 2-4 ha of land, which depends upon resources available, manual labor, etc. Some landlords distribute 2 ha of land proportionate to tenants who can contribute 2 bullocks for manual labor. Tenants who have their own pairs of bullocks can contribute towards the cost of chemicals and fertilizers and have the right to receive fifty percent of the output.

Table 33. Percentage Share of Tenants in Inputs and Output in the Sindh Province (1997-98).

Type Of Tenure	Abiana	Chemical	Fertilizer	Labor	Tillage	Seed	Transport	FYM	Other	Reclamation	Tubewell	Yield
25%	0	25	25	25	0	25	25	100	0	0	0	25
50%	0	50	50	100	100	100	50	100	50	0	0	50

The liability of payment for water rates rests with the owner. Tenants do not pay water rates for major crops, but in some areas tenants have to pay abiana (water rates) for the area used to cultivate fodder crops for his livestock. Tenants work on the farm as labor and have limited decision-making power.

f). Lessee

Lessees also do not have their own land. They hire land for a fixed cash payment, which is valid for one year only if they get land from farmers. This may be valid for long periods of time if they hire land from the government. Lessees have the authority to make decisions about land use and the input use pattern. Most times, lessees work on their farms but there are occasions when lessees have tenants.

g). Managers

Managers are not farmers; they manage land belonging to feudal lords (absentee landlords). Responsibilities of the manager include providing inputs to tenants, to manage farm accounts, to coordinate between the landlord and tenant, to collect the share of the output from tenants, to look after farm resources, etc.

h). Others

Farmers in this category belong to more than one tenurial class. They may be owner-cum-manager, lessee-cum-owner cultivator or lessee-cum-owner manager, etc.

7) Current Status of Land Tenure in the Sindh Province

Out of 801,975 farms in Sindh, about 50 percent (405,804) are operated by owners, about 42 percent (334,918) by tenants and the remaining 8 percent (61,253) are managed by OCT (Census of Agriculture, (1990). The survey sample results contain about 68 percent owner farms, 4 percent OCT and 28 percent tenant farms among 68 percent of owner farms (Table 34), 1 percent absentee landlords, 20 percent owner-managers, 43 percent owner-cultivators, and 4 percent were managers of absentee landlords.

Table 34. Number and Percentage of Farms in each Tenurial and Farm Size Class in the Sindh Province (1997-98).

	Small	Medium	Large	Extra Large	Total
Owner-cum-Tenant	6 (2)	46 (6)	10 (3)	1 (1)	63 (4)
Owner	161 (62)	428 (54)	305 (91)	150 (97)	1044 (68)
Tenant	93 (36)	316 (40)	19 (6)	4 (3)	432 (28)
Total	260 (100)	790 (100)	334 (100)	155 (100)	1539 (100)

Figures in parenthesis represent the percentage distribution.

Table 35 reveals that absentee landlords (plus managers) are totally absent in small farms and their presence increases as farm sizes increase. The owner-farm-manager category increases, but the percentage of owner-managers declines in the extra-large category. The owner-cum-tenant category does not form a major part of the farm population. The percentage of OCT is highest in medium farms (6 percent). Most OCT farms hire some land to qualify for the category of medium farms. Tenants show the same trend as for OCT, i.e. the highest in medium sized farms (40 percent). The overall population of lessees does not lease land for cultivation on the Right Bank while some farmers on the Left Bank acquire land on rent. But, most times, they prefer to hire land on share bases instead of at fixed land rent.

Table 35. Distribution of Sample Farmers among different Farm Categories in the Sindh Province (1997-98).

Farm categories	Small	Medium	Large	Xlarge	Total
Absentee.Landlord	0 (0.00)	1 (0.06)	5 (0.32)	2 (0.13)	8 (1)
Owner managers	10 (0.65)	75 (4.87)	140 (9.10)	84 (5.46)	309 (20)
Owner cultivators	152 (9.88)	349 (22.68)	140 (9.10)	18 (1.17)	659 (43)
Owner cum tenants	6 (0.39)	46 (2.99)	10 (0.65)	1 (0.06)	63 (4)
Tenants	94 (6.11)	313 (20.34)	16 (1.04)	2 (0.13)	425 (28)
Lessees	0 (0.00)	2 (0.13)	3 (0.19)	2 (0.13)	7 (0)
Managers	0 (0.00)	1 (0.06)	20 (1.30)	46 (2.99)	67 (4)
Others	0 (0.00)	1 (0.06)	0 ((0.00))	0 (0.00)	1 (0)
Total	262 (17.02)	788 (51.20)	334 21.70	155 (10.07)	1539 (100)

Figures in parenthesis represent percentage distribution of farms in tenurial and land size classes.

Table 36 presents the current status of farm tenure in the Sindh Province with respect to the farm size categories. In small farms, owner-cultivators are the most common, i.e. 58 percent, because they cannot afford to employ managers, nor can they share such small farms with tenants. When compared to owner-cultivators, owner-managers are not present on those farms so frequently. Here, the data reveals the incidence of a direct relationship between the size of the farm and the employment of a manager, i.e. as the farm size increases, large farmers tend to employ managers on their farms. Therefore, the percentage of managers increases with an increase in the farm size and the percentage of owner-cultivators decreases with the increase in farm size.

Table 36. Distribution of Farms in different Farm Size Classes in the Sindh Province (1997-98).

Farm categories	Small	Medium	Large	X-large	Total
Absentee Landlords	0	1	5	2	8
	(0.00)	(0.13)	(1.50)	(1.29)	(1)
Owner .managers	10	75	140	84	309
	(3.82)	(9.52)	(41.92)	(54.19)	(20)
Owner Cultivators	152	349	140	18	659
	(58.02)	(44.29)	(41.92)	(11.61)	(43)
Owner Cum Tenants	6	46	10	1	63
	(2.29)	(5.84)	(2.99)	(0.65)	(4)
Tenants	94	313	16	2	425
	(35.88)	(39.72)	(4.79)	(1.29)	(28)
Lessees	0	2	3	2	7
	(0.00)	(0.25)	(0.90)	(1.29)	(0)
Managers	0	1	20	46	67
	(0.00)	(0.13)	(5.99)	(29.68)	(4)
Others	0	1	0	0	1
	0.00	0.13	0.00	0.00	0
Total	262	788	334	155	1539
	100.00	100.00	100.00	100.00	100

Figures in parenthesis represent percentage distribution.

Table 37. Comparison of Tenurial Status on Both Banks of the Indus River in the Sindh Province (1997-98).

Farm categories	Left Bank	Right Bank	Sindh
Absentee .Landlords	7	1	8
	(0.71)	(0.18)	(0.45)
Owner managers	221	88	221
	(22.44)	(15.88)	(14.36)
Owner Cultivators	443	216	443
	(44.97)	(38.99)	(28.78)
Owner-Cum-Tenants	19	44	19
	(1.93)	(7.94)	(1.23)
Tenants	246	179	246
	(24.97)	(32.31)	(15.98)
Lessees	7	0	7
	(0.71)	(0.00)	(0.45)
Managers	42	25	42
	(4.26)	(4.51)	(2.73)
Others	0	1	0
	(0.00)	(0.18)	(0.00)
Total	985	554	1539
	(100.00)	(100.00)	(100.00)

Figures in parenthesis represent percentage distribution of farms in tenurial and size classes

Farm tenure is somewhat different on both sides of the Indus River in the Sindh Province. If we compare data on the Left and Right Banks, a difference in the tenurial system on both sides is visible. The number of absentee landlords is greater than on the Right Bank. The results of the study revealed that, on average, farm holdings are small but land is still cultivated by tenants. Farmers on the Right Bank did not report acquiring land on a lease basis, therefore, the number of lessees on the Right Bank was zero. However, Table 37 shows that this class is present as reported by 7 lessees. Villages on the Right Bank are well developed and populous and have access to towns and cities. Therefore, the villagers reported that they have opportunities to work out-side the agriculture sector. These people are not engaged in agricultural land on share bases to other owner-farmers or land-less farmers. Therefore, OCT and tenants on the Right Bank are more than on the Left Bank. Another reason for this may be that more feudal lords reside on the Right Bank, who are reported to have a strong hold on their tenants. Tenants were found reluctant to give any responses without prior permission from their landlords.

8) Cropping Pattern in the Sindh Province (1997-98)

The cropping pattern differs on both sides of the river Indus; different crops are being grown on the Left and Right Banks. Wheat, cotton and sugarcane are the major crops on the Left Bank, while wheat and rice are the major crops on the Right Bank of the Indus River. The survey results showed that the cotton crop is not grown on the canal commands of the Begari, Dadu, Desert, Northwest, Rice, Pinyari, and Fuleli Canals because these canal commands have fine-textured soils and high watertable. The highest percentage of area under cotton crop was found in the Ghotki, Jamrao, Nara and Rohri Canal commands. The cropping pattern in these areas is wheat-cotton. A considerable percentage of sugarcane was also found in those areas. On the Right Bank, rice is the only Kharif crop, therefore, major share of area under rice crop comes from the Begari, Desert and Northwest Canals, while in Rabi the farmers reported that the majority of the farms do not sow the wheat crop due to excess moisture in the soil at the harvesting of rice. Therefore, farmers grow oilseeds in those areas as a Zaid Rabi (late Rabi) crop where they could not grow the wheat. The fodder crops are reported grown by tenants and by owner-cultivators for their livestock. Other crops reported by the farmers include onion, chilies, vegetables, pulses, etc. Orchards include date-palm, banana and hina.

Table 38 shows the distribution of cultivated area under different crops, which indicates the major crops of specific canal commands. About 98 percent of area is found to be covered by the rice crop in the Begari, Desert, and Rice Canals in Kharif, while the Dadu Canal has 78 percent and the North West Canal 92 percent area under rice crop.

Cotton occupies 54 percent of the area in the Ghotki, 31 percent in the Nara, 30 percent in the Jamrao and 29 percent in the Rohri, 54 percent in the Khairpur East and 19 percent in the Khairpur West Canal commands. The cropping pattern in these canal command areas is Wheat-Cotton. However, sugarcane is also grown there. The cultivated area under sugarcane crop was found to be 40 percent in the Lined Channel, 36 percent in the Pinyari and 27 percent in the Fuleli Canal, among canals of the Sukkur Barrage. The Rohri Canal command had the highest; 24 percent. On the Right Bank of the River Indus, only the Dadu Canal had 10 percent of its cultivated area under sugarcane. In the remainder of the canal command areas of the Right Bank, sugarcane is either totally absent or found on a very small area like that of the Northwest Canal, where sugarcane covers only one percent of the GCA.

The wheat crop, being the staple food, is found to be present on every canal command. Orchards are common in commanded areas of the Khairpur and Nara Canals. In the Rabi season the wheat crop is grown with oilseed in the canal command areas of the Right Bank. The farmers on the Right Bank grow wheat only for home consumption and after the paddy harvesting, the wheat crop is reported to be sown with zero tillage.

Table 38. Area under Crop as Percentage of Cultivated Area in different Canal Commands in the Sindh Province (1997-98).

Canal	Area under crop as percentage of cultivated area total								Cultivated
Command	Cotton	Rice	Sugarcane	Wheat	Oil Seed	Orchard	Fodder	Others	Area
Begari	0	98	0	62	4	0	3	6	5410
Dadu	2	78	10	61	1	0	15	9	88
Desert	0	98	0	74	5	0	1	6	2079
North West	1	92	1	29	13	0	11	7	2576
Rice Canal	0	98	0	29	36	0	12	13	788
Fuleli	2	43	27	17	15	0	9	5	1025
Ghotki	54	5	19	55	1	0	4	0	2543
Jamrao	30	1	11	33	3	10	8	5	5173
Khairpur East	54	4	13	64	0	17	21	0	284
Khairpur West	19	16	11	46	1	25	24	3	330
Lined Channel	2	37	40	20	0	0	12	1	756
Nara	31	1	7	34	1	5	8	5	5475
Pinyari	0	39	36	12	0	0	5	0	443
Rohri	29	4	24	30	1	8	8	4	7511
Sindh	21	35	12	40	4	4	7	5	34482

The area under sugarcane crop was found to be more in areas where rice is grown less intensively. The cultivation of sugarcane was found more common in the cotton-wheat zone instead of the rice-wheat zone, because most soils in the cotton-wheat zone (on the Left Bank of the River Indus) are reported to be medium-textured soils most suitable for the sugarcane crop.

9) CROPPING INTENSITY

In the Sindh Province the cropping intensity varies from 105 percent in the Nara to 192 percent in the Rice Canal. The canal command areas (CCA) of the Right Bank were found having a higher cropping intensity than that of the CCA on the Left Bank because farmers on the Right Bank the sow the rice crop on almost all of the farm area. In Rabi they have enough moisture to broadcast the wheat seed or sarsoon seed in the paddy field just after the harvesting of the rice crop. The wheat seeds thrown in the paddy fields use the same moisture already present in the soil. The wheat crop is raised in zero tillage without any irrigation, or even without fertilizers. In contrast, on the Left Bank of the Indus River at tail reaches of the Nara and Rohri, Jamrao, Lined Channel and Fuleli Canal commands, the farms reported acute shortages of irrigation water in the Kharif season. Therefore, the cropping intensity in Kharif never exceeds 60 percent in these canal commands. The cropping intensity in all of the three canals of the Kotri Barrage during the Rabi season is reported to be the lowest of all. The low cropping intensity in the Kharif season is due to the high intensity of sugarcane in these canal commands. Sugarcane covers a good percentage of cultivated area in these canal commands. The canal command on the Right Bank prohibits the cultivation of the sugarcane because of the high watertable and finer soil, which is more suitable for the rice-wheat cropping pattern. The canal commands in which Rabi, Kharif and sugarcane area do not form annual cropping intensity have some percentage of area under orchards. The presence of the orchards usually increase the cropping intensity because farms prefer to sow fodder crops in orchard; in this way, the cropping intensity may reach 300 percent.

Table 39. Average Cropping Intensity and Percentage of Cultivated area under Kharif, Rabi Crops and Sugarcane Crop in the Canal Commands of the Sindh Province (1997-98).

Canal Commands	Cropping Intensity	Percentage of Cultivated Area under			
		Kharif Crops	Rabi Crops	Sugarcane	Orchard
Begari	180	96	82	0	0
Dadu	170	81	80	8	0
Desert	190	96	93	0	1
Fuleli	123	56	34	32	0
Ghotki	183	91	88	3	1
Jamrao	131	52	62	11	3
Khairpur East	182	77	83	8	12
Khairpur West	166	47	69	12	34
Lined Channel	115	43	28	44	0
Nara	106	49	49	4	2
North West	170	94	73	1	0
Pinyari	124	56	30	38	0
Rice Canal	192	99	91	0	0
Rohri	144	56	61	19	6
Sindh	**158**	**74**	**70**	**10**	**4**

10) Mechanization

The increase in the population enhanced the pressure on agriculture and made it necessary to transit from old primitive agriculture (based on indigenous implements) to advanced mechanization (based on new implements and tools). During the survey in Sindh, the farmers reported the use of different agricultural implements from the land preparation to the harvesting and threshing of crops. These implements have become an essential part of agriculture due to the uncertain weather conditions, narrow time limits (between harvesting one crop and sowing another) and increased cropping intensity. The important agricultural implements being used in Sindh are Gobal (disk harrow), Cultivator, Leveler, Punj Phara (Five tined cultivator) and Sohaga (Wooden Plank). The use of the disk plough is very limited and is reported to be used by the landowners only, after 2-3 years. A very small number of farmers reported the use of tractor-driven seed drills for sowing of cotton. The majority of the farmers reported the use of bullock-driven drills for the sowing of cotton. Similarly, the interculture/hoeing of sugarcane and cotton is also reported to be done with bullocks. The harvesting of the wheat and other crops is reported to be done manually. About 100 percent of wheat threshing is reported to be done with the wheat thresher. The Gobal is reported to be the main implement used by 46 percent of farmers for land preparation in the canal commands of the Left Bank of the Indus River. Of these users, 78 percent hired the Gobal and only 22 percent used their own Gobals. The cultivator (Eleven tined) is reported to be used widely on both sides of the Indus River in the Sindh Province. About 81 percent of the farmers reported the use of the cultivator to cultivate their fields. The Punj Phara is reported to be used on the Right Bank of the Indus River (in the rice-wheat cropping zone). Almost 67 percent of farmers in the Sindh Province reported the use of the Punj Phara for land preparation. The concept of using Punj Phara is somewhat different on both sides of the River Indus. On the Left Bank this implement is large in size and is used for deep tillage, while on the Right Bank it is used as a cultivator. As all these implements are operated with tractors it has special importance in crop production and agriculture development. But, in Sindh, few farmers own tractors. The reason may be that most of the land is cultivated by tenants who share a small acreage (2-4 ha). These tenants either operate their farms with bullocks or with hired tractors. Under the tenancy contract, the land preparation is the responsibility of the tenants.

Table 40. Farmers Reporting the Use of Agricultural Machinery.

Implements	Total Farms	Farms reporting the use of implements		
		Total	Hired	Owned
Gobal	1539	709 (46)	551 (78)	158 (22)
Keen	1539	1071 (70)	822 (77)	249 (23)
Punj Phara	1539	1035 (67)	807 (78)	228 (22)
Cultivator	1539	1244 (81)	969 (78)	275 (22)
Sohaga	1539	391 (25)	264 (68)	127 (32)
Bullock	1539	349 (23)	107 (31)	242 (69)

Figures in parenthesis represent the percentage distribution of the sample farms.

The survey results showed that only the large owner-cultivator farmers were using their own tractors; the remaining farms were dependent on hiring tractors for performing different farm operations. The total number of tractors in Sindh was 16,542 in 1984 and of these, 462 are owned by the Government and the remainder by private landlords (Farm machinery Census, 1984).

VI LAND USE INEFFICIENCIES AND THE PRODUCTION POTENTIAL IN THE SINDH PROVINCE

After the inception of the green revolution (the introduction of new bio-chemical technologies) and large investments in water development, there was a significant improvement in the cropping intensity and crop yields in the Sindh Province. The enhanced water availability contributed to increases in both, cropping intensity and crop yields. The provision of more water supplies also helped to bring more land under cultivation. The 1990 census data reveals that despite all efforts to increase the cultivated area in the Sindh Province, the total cultivated area in 13 districts amounted to 2.85 Mha out of the 3.46 Mha of farmland (Tables 41 & 42). Still, there were 0.566 Mha of land on agricultural farms that could be cultivated, but are classified as culturable waste. Since the cultivated areas are approaching their limits in cropping intensity, the chance to increase agricultural production in the province by bringing these culturable wastelands under agriculture does exist. Tables 41 and 42 provide figures pertaining to the total number of farm holdings, farm size and culturable wasteland, which provide insights regarding the pattern of agricultural land use and its distribution within the Sindh Province. Tables 4 and 5 in Section I showed that in Sindh about 6 percent of the large farms were having about 36 percent of the land holding, while 60 percent of medium farms and 33 percent of small farms were having about 55 and 9 percent of land holdings, respectively. This also shows the distribution of farms across farm size groups on the Left and Right Banks of the River Indus, as well as across 13 districts in the Sindh Province.

The figures Table 42 reveals that overall the culturable waste area increases as the farm size increases. The 1990 census data in Table 42 shows that on an average, the culturable waste area on small, medium and large farms turn out to be about 2, 34 and 64 percent, respectively, in Sindh. Similar is the trend with respect to the Left and the Right Bank areas as well as across 13 districts in Sindh. The data shows that during the census year 1990, about 16 percent of the total area on agricultural farms was not used at all and remained culturable waste. Regarding the distribution of cultivated and culturable waste area, Table 42 shows that the highest percentage of cultivated area is located in the District Tharparkar (23 percent), followed by Districts Hyderabad, Jaccobabad, Sanghar and Badin (about 9 percent each), Khairpur and Dadu (about 6 percent, each) followed by the District Thatta (5 percent), Nawabshah (4 percent), Sukkur and N. Feroze (3 percent), and Shikarpur (2.6 percent). For the culturable waste, more than 58 percent of the distribution is in Districts Dadu, Sanghar and Tharparkar; the highest occurrence being on large farms. This trend persists at all levels, and leads to the conclusion that as the farm size increases, the area under culturable waste also increases. Similar results are revealed from Table 43, which shows the distribution of farm area among small, medium and large farm categories across 14 canal commands in the Sindh Province. Table 43 shows that about 32 percent of the large farms (10-60 ha) and Extra-large farms (>60 ha) were owning about 90 percent of the sample farm area when compared to the small and medium farms who were owning 10 percent of the sample farm area in the Sindh Province. Table 43 and 44 show that about 66 percent of the sample farm area is located in the canal commands of the Rohri, Begari, Jamrao and Nara Canals and again, show similar trends of culturable waste area with respect to the farm size.

Table 41. Farm Size-wise Distribution of Farm Numbers and Total Farm area across Districts in the Sindh Province (1990).

Districts		Farm size categories			Total	Total
		Small	Medium	Large	Farm number/	
		%	%	%	Farm area (ha)	%
BADIN	FNO	25.10	66.93	7.98	62813	7.85
	FAT	6.91	55.85	37.24	323808	9.35
HYDERABAD	FNO	26.89	66.11	7.00	61874	7.73
	FAT	7.64	52.69	39.67	302073	8.72
KHAIRPUR	FNO	55.80	41.53	2.67	69430	8.68
	FAT	21.12	58.95	19.93	180915	5.22
N FEROZ	FNO	47.16	48.69	4.15	32327	4.04
	FAT	14.38	56.81	28.82	107049	3.09
NAWABSHAH	FNO	27.32	59.11	13.57	19153	2.39
	FAT	5.25	41.28	53.47	123861	3.58
SANGHAR	FNO	13.11	76.11	10.78	51152	6.39
	FAT	2.75	48.38	48.87	334845	9.67
SUKKUR	FNO	46.86	50.25	2.89	67492	8.44
	FAT	15.85	64.64	19.51	193503	5.59
THARPARKAR	FNO	18.98	67.49	13.53	124795	15.60
	FAT	3.23	48.52	48.25	820836	23.71
LEFT BANK	**FNO**	**31.90**	**60.40**	**7.70**	**552260**	**69.03**
	FAT	**7.14**	**52.03**	**40.83**	**2084816**	**60.21**
DADU	FNO	35.62	59.56	4.81	63224	7.90
	FAT	11.68	61.49	26.84	236172	6.82
JACCOBABAD	FNO	24.73	72.38	2.89	81575	10.20
	FAT	9.79	71.34	18.87	282584	8.16
LARKANA	FNO	44.99	52.41	2.60	88787	11.10
	FAT	18.17	63.62	18.21	261337	7.55
SHIKARPUR	FNO	46.71	50.77	2.52	28832	3.60
	FAT	20.00	58.46	21.54	76270	2.20
THATTA	FNO	33.57	60.40	6.03	48566	6.07
	FAT	9.44	52.42	38.14	219416	6.34
RIGHT BANK	**FNO**	**36.28**	**60.36**	**3.36**	**247760**	**30.97**
	FAT	**11.74**	**60.37**	**27.89**	**1377851**	**39.79**
SINDH	**FNO**	**33.26**	**60.39**	**6.36**	**800020**	**100.00**
	FAT	**8.97**	**55.35**	**35.68**	**3462667**	**100.00**

Source: Agricultural Census of Pakistan, 1990.

Table 42. Distribution of the Cultivated Area and the Cultivable Waste Area across Districts in the Sindh Province (1990).

Districts		Small	Medium	Large	Total	Percentage
		%age	%age	%age	(ha)	Distribution
BADIN	CAT	8.99	60.12	30.89	235922	8.3
	CWA	1.31	44.43	54.27	86294	15.2
HYDERABAD	CAT	8.93	57.30	33.77	251600	8.8
	CWA	0.90	29.18	69.92	44389	7.8
KHAIRPUR	CAT	21.86	59.13	19.02	172884	6.0
	CWA	5.61	59.47	34.92	2757	0.5
N FEROZ	CAT	15.41	58.74	25.85	90646	3.2
	CWA	8.98	46.62	44.41	15502	2.7
NAWABSHAH	CAT	5.70	42.89	51.41	111138	3.9
	CWA	1.41	27.14	71.44	11979	2.1
SANGHAR	CAT	3.55	58.70	37.75	245756	8.6
	CWA	0.54	19.79	79.67	86627	15.3
SUKKUR	CAT	16.84	64.82	18.34	172477	6.0
	CWA	7.92	63.70	28.38	19892	3.5
THARPARKAR	CAT	3.73	54.58	41.70	655422	22.9
	CWA	1.31	24.51	74.18	159938	28.2
LEFT BANK	**CAT**	**8.47**	**56.97**	**34.56**	**1935845**	**67.7**
	CWA	**1.76**	**31.25**	**66.98**	**427378**	**75.5**
DADU	CAT	13.97	67.27	18.76	186632	6.5
	CWA	3.25	40.71	56.03	43532	7.7
JACCOBABAD	CAT	10.50	72.68	16.82	257027	9.0
	CWA	3.16	60.22	36.62	21546	3.8
LARKANA	CAT	18.70	64.38	16.93	252623	8.8
	CWA	3.14	42.26	54.60	8246	1.5
SHIKARPUR	CAT	20.47	59.62	19.91	74418	2.6
	CWA	0.81	7.81	91.38	1741	0.3
THATTA	CAT	11.49	59.71	28.81	151942	5.3
	CWA	5.01	37.41	57.58	59811	10.6
RIGHT BANK	**CAT**	**14.41**	**66.12**	**19.47**	**922642**	**32.3**
	CWA	**3.98**	**42.03**	**53.99**	**134876**	**23.8**
SINDH	**CAT**	**10.39**	**59.93**	**29.69**	**2858487**	**100.0**
	CWA	**2.29**	**33.82**	**63.89**	**566333**	**100.0**

Table 43. Farm Size-wise Distribution of Total Farm Area across Canal Commands in the Sindh Province (1998).

(ha)

Canal Command	Small		Medium		Large		X-large		Total	
	No.	Area	No.	Area	No.	Area	No.	Area	No.	Area
Begari	28	47	74	351	34	897	30	6058	166	7353
	(17)	(.63)	(45)	(4.77)	(20)	(12.2)	(18)	(82.4)	(100)	(100)
Dadu	17	26	10	35	4	50	0	0	31	112
	(55)	(23.63)	(32)	(31.76)	(13)	(44.61)	(0)	(0)	(100)	(100)
Desert	6	11	37	168	10	514	8	2115	61	2807
	(10)	(.37)	(61)	(5.98)	(16)	(18.31)	(13)	(75.34)	(100)	(100)
North West	23	33	104	560	54	1519	12	2034	193	4145
	(12)	(.79)	(54)	(13.51)	(28)	(36.64)	(6)	(49.06)	(100)	(100)
Rice	29	42	57	255	14	375	3	627	103	1299
	(28)	(3.22)	(55)	(19.63)	(14)	(28.87)	(3)	(48.28)	(100)	(100)
Right Bank	103	158	282	1369	116	3354	53	10834	554	15715
	(19)	(1)	(51)	(8.72)	(21)	(21.34)	(10)	(68.94)	(100)	(100)
Fuleli	9	17	36	195	22	498	7	849	74	1559
	(12)	(1.09)	(49)	(12.49)	(30)	(31.93)	(9)	(54.49)	(100)	(100)
Ghotki	46	63	111	571	22	453	7	2193	186	3280
	(25)	(1.92)	(60)	(17.39)	(12)	(13.81)	(4)	(66.88)	(100)	(100)
Jamrao	8	14	54	300	45	1152	21	5117	128	6583
	(6)	(.21)	(42)	(4.56)	(35)	(17.51)	(16)	(77.72)	(100)	(100)
Khairpur E	31	39	44	213	4	62	0	0	79	313
	(39)	(12.52)	(56)	(67.86)	(5)	(19.62)	(0)	(0)	(100)	(100)
Khairpur W	30	29	25	135	10	216	0	0	65	381
	(46)	(7.55)	(38)	(35.57)	(15)	(56.88)	(0)	(0)	(100)	(100)
Lined Ch.	2	4	29	262	20	537	5	431	56	1234
	(4)	(.29)	(52)	(21.25)	(36)	(43.54)	(9)	(34.92)	(100)	(100)
Nara	6	10	42	240	33	1034	24	5266	104	6550
	(6)	(.15)	(40)	(3.66)	(32)	(15.79)	(23)	(80.4)	(100)	(100)
Pinyari	4	4	14	82	3	62	4	498	25	646
	(16)	(.66)	(56)	(12.72)	(12)	(9.53)	(16)	(77.09)	(100)	(100)
Rohri	21	35	153	764	59	1419	34	7127	267	9346
	(8)	(.38)	(57)	(8.17)	(22)	(15.18)	(13)	(76.27)	(100)	(100)
Left Bank	157	215	508	2762	218	5433	102	21482	985	29891
	(16)	(0.72)	(52)	(9.24)	(22)	(18.17)	(10)	(71.87)	(100)	(100)
Sindh	260	372	790	4131	334	8787	155	32316	1539	45606
	(17)	(0.81)	(51)	(9.06)	(22)	(19.27)	(10)	(70.86)	(100)	(100)

Source: IIMI-Sindh Salinity Survey, 1997-98.

Note: Figures in parenthesis are the percentage distribution of farm/area with respect to the total number of farms/area.

Table 44. Distribution of the Cultivated Area and the Cultivable Waste Area across Canal Commands in the Sindh Province (1998).

Canal Command	Small		Medium		Large		Xlarge		Total		Total	
	CAT*	CWA*	CAT	CWA	CAT	CWA	CAT	CWA	CAT	CWA	CAT	CWA
	%	%	%	%	%	%	%	%	%	%	(ha)	(ha)
Begari	1	0	6	1	14	8	79	91	15.71	17.41	5410	1942
Dadu	30	2	38	8	32	91	0	0	0.25	0.22	88	24
Desert	1	0	7	2	23	5	69	93	6.03	6.52	2079	728
North West	1	0	18	5	46	21	34	73	7.48	14.06	2576	1568
Rice	5	0	30	4	34	21	31	74	2.29	4.58	788	511
Right Bank	1	0	11	3	25	14	63	83	31.76	42.79	10941	4773
Fuleli	1	1	15	8	34	28	50	63	2.97	4.79	1025	534
Ghotki	2	0	21	6	14	12	63	81	7.37	6.66	2537	743
Jamrao	0	0	5	4	16	24	79	72	15.02	12.63	5173	1410
Khairpur East	13	5	65	95	22	0	0	0	0.82	0.26	284	30
Khairpur West	8	7	37	25	55	69	0	0	0.96	0.45	330	50
Lined Channel	0	0	23	19	47	38	30	43	2.19	4.29	756	479
Nara	0	0	4	1	15	21	81	78	15.89	9.64	5475	1075
Pinyari	1	1	15	7	13	3	71	89	1.29	1.82	443	203
Rohri	0	0	9	3	15	17	75	79	21.73	16.68	7485	1860
Left Bank	1	0	10	6	17	21	72	73	68.24	57.21	23508	6383
Sindh	1	0	11	5	20	18	69	77	100.00	100.00	34449	11156

Source: IIMI-Sindh Salinity Survey, 1997-98.
*CAT = Cultivated Area Total
*CWA = Culturable Waste Area

The following discussion focuses on the statistical significance of the relationship existing between the farm size and culturable waste area by using the dis-aggregated district data.

A. Spatial and Temporal Relationships of Culturable Waste Area in Sindh

1) Farm Size and its Relationship with the Culturable Waste Areas in the Sindh Province

The regression results derived through the regression Equations 7 and 8 (which relate the culturable waste area with farm size and the irrigated area, as already specified in Section E of Chapter I of this report) are summarized in Tables 45 and 46. Equation 7 in the model captures the effect of farm size on the CWA, whereas Equation 8 examines the CWA relationship with increases in irrigation supplies in the Sindh Province. The summary of the results in Table 45 shows that the regression equations for all of the districts and across Sindh have expected signs and magnitude for the estimated parameters. The explanatory power (adjusted R^2) is 0.64, 0.77, 0.83, 0.86, 0.90, 0.92, 0.89, 0.84, 0.96, 0.94, 0.77 and 0.91 for Districts Badin, Dadu, Hyderabad, Jaccobabad, Khairpur, Larkana, Nawabshah, Sanghar, Shikarpur, Sukkur, Tharparkar, and Thatta, respectively. For the Left Bank and the Right Bank area the value of the adjusted R^2 is 0.78 and 0.75, respectively. At the overall Sindh level, the value of the adjusted R^2 is 0.77.

At the Left and Right Bank area levels, as well as at the overall Sindh level, the postulated direct relationship between farm sizes and culturable wastelands is empirically valid during the time periods of the 1960s, 1970s and 1980s (before, during and after the Green Revolution/SCARP/drainage projects). Surprisingly, during the 1970s and ten years after the Green Revolution, the CWA has increased in the Sindh Province as the coefficient for FAT80 is positive, higher than FAT72 and statistically significant at the 99 percent level of confidence. One of the reasons might be that secondary salinization (due to the exploitation of the bad quality groundwater) or the drainage problem are present in the majority of the areas on both, the Right and Left Banks of the Indus Rover in the Sindh Province. The elasticity coefficients for the farm sizes in the 1960s are statistically significant in all of the 12 districts at the 99 percent level of confidence, and have the positive signs. The magnitude of the coefficient for the farm area being greater than 1 for all the districts show that a one percent increase in the farm size in these districts led to more than a 1 percent increase in the CWA.

Table 45 shows the positive value of FAT72 for the districts of Jaccobabad, Sanghar and Sukkur and the increasing trend in CWA during the 1970s on the Left Bank of the Indus River in Sindh. While, in the case of the Right Bank area, the trend remains the same as during the1960s. The districts of Larkana, Nawabshah, Sukkur and Thatta show positive coefficients for FAT80, indicating an increasing trend in the culturable waste during the 1980s in theses districts (Table 45). In the case of the 1990s, all the districts have negative coefficients showing the declining trend in the culturable waste area with respect to the farm area total, except the District Shikarpur. In this case, the coefficient for FAT90 was positive, showing the positive relationship between the increase in the farm area and the culturable waste area, which has an increasing trend even during the 1990s.

Table 45. Regression Results Relating the Farm Area with the Culturable Waste Area in the Sindh Province (1960-1990).

	Constant	DV70-72	DV80	DV90	LNAFAT	LNAFAT72	LNAFAT80	LNAFAT90	Fcalc	Adj R^2	DF Total
Badin	-2.63*			1.41*	1.23*				15.24	0.64	16
	(0.74)			(0.75)	(0.22)						
Dadu	-2.66*			2.06*	1.38*			-0.56*	39.82	0.77	33
	(0.45)			(0.62)	(0.14)			(0.22)			
Hyderabad	-3.34*			1.39*	1.39*				80.55	0.83	32
	(0.36)			(0.43)	(0.11)						
Jaccobabad	-3.59*	-3.59*		1.55*	1.48*	0.78*		-0.50*	43.20	0.87	32
	(0.40)	(1.03)		(0.66)	(0.13)	(0.32)		(0.22)			
Khairpur	-3.62*				1.32*				323.75	0.90	34
	(0.22)				(0.07)						
Larkana	-3.25*		-1.46*	-0.09*	1.42*		0.34*		101.04	0.92	35
	(0.29)		(0.55)	(0.35)	(0.08)		(0.18)				
Nawabshah	-3.30*	-0.66*	-2.38*		1.29*		0.54*		70.89	0.89	32
	(0.30)	(0.34)	(0.66)		(0.96)		(0.21)				
Sanghar	-3.84*	-2.52*		1.30*	1.49*	0.67*			44.04	0.85	31
	(0.43)	(1.09)		(0.46)	(0.13)	(0.33)					
Shikarpur	-5.56*			-2.87*	1.79*			0.50*	143.45	0.97	14
	(0.40)			(0.64)	(0.13)			(0.20)			
Sukkur	-2.53*	-2.57*	-2.10*		1.18*	0.62*	0.46*		111.95	0.94	33
	(0.22)	(0.49)	(0.48)		(0.07)	(0.16)	(0.16)				
Tharparkar	3.52*		-1.07*	4.01*	1.54*			-1.32*	31.01	0.77	34
	(0.47)		(0.55)	(0.66)	(0.14)			(0.25)			
Thatta	-3.22*	0.72*		1.77*	1.36*		0.21*		88.61	0.91	34
	(0.27)	(0.34)		(0.35)	(0.08)		(0.11)				
Left Bank	-2.95*	-1.59*	-1.41*	1.59*	1.26*	0.37*	0.32*	-0.41*	121.06	0.78	227
	(0.27)	(0.45)	(0.39)	(0.33)	(0.08)	(0.14)	(0.13)	(0.12)			
Right Bank	-3.50*			1.26*	1.48*			-0.48*	158.86	0.76	152
	(0.23)			(0.38)	(0.07)			(0.13)			
Sindh	-2.96*	-1.14*	-1.23*	1.29*	1.30*	0.27*	0.29*	-0.40*	181.53	0.77	380
	(0.22)	(0.3)	(0.32)	(0.28)	(0.07)	(0.11)	(0.10)	(0.09)			

Note:
The figures in parenthesis are the standard errors.
Coefficients are significant at 99 percent level of confidence.

The intercept term and intercept dummies have negative signs and the coefficients are significant for 1972 and 1980, meaning that technological developments led to a decrease in the CWA within the Sindh Province during the 1970s and 1980s. In the case of the Jaccobabad, Larkana, Nawabshah, Sanghar and Sukkur Districts, the technology did play a role in reducing the CWA till the 1970s and 1980s. The results show that for all the districts, except Larkana and Shikarpur, the technology did play a role until the 1980s, and afterwards not, as the 1990 intercept dummies were non-negative and significant at the 99 percent level of confidence for these districts. Table 45 also shows that overall, the intercept dummy was also negative for 1972 and 1980, and was positive for the intercept dummy of 1990 showing that the technological development did not play any role in reducing the CWA during the 1990s.

2) Irrigation Supplies and its Impact on the Culturable Waste Area in the Sindh Province

Based on Equation 8 (which relates the culturable waste area with farm size and the irrigated area, as already specified), Table 46 shows that the log-linear regression equations (relating the CWA with FAT and CAI) for all of the districts and the overall Sindh Province have high explanatory power and the expected signs and magnitude for the estimated parameters. The elasticity coefficients for the farm sizes showed a positive relationship between farm size and the CWA in all of the districts. Table 46 shows that there was no significant change in the relationship between farm size and CWA in the districts of Badin, Dadu, Hyderabad, Sanghar and Thatta when compared with elasticity coefficients for farm sizes in the 1960s.

For the Jaccobabad and Sukkur Districts, the elasticity coefficients for the farm sizes during the 1970s and 1980s showed an increasing trend in the CWA, with increasing farm size that further increased thereafter. In Nawabshah District, the coefficient shows an increasing trend of culturable waste area until the 1980s and afterwards declines during the 1990s. For Districts Khairpur, Larkana, Shikarpur and Tharparkar, Table 46 shows a similar trend of CWA with respect to FAT during the 1960s, but this trend decreases during the 1980s in the case of Khairpur and Shikarpur, and further declines in the districts of Khairpur, Larkana, Shikarpur and Tharparkar.

At the same time it is observed from Table 46 that the proportion of area under irrigation has a negative and statistically significant (at the 99 percent level of confidence) relationship with CWA during the 1960s in Districts Dadu, Khairpur, Larkana, and Sukkur and this relationship becomes more negative afterwards during the 1980s and 1990s. In all of the other districts, the elasticity coefficients for the proportion of irrigated areas on the farms were not significant.

In the case of the Right Bank of the Indus River in the Sindh Province, the coefficients for the proportionate area under irrigation was also non-significant during the 1960s, but became positive during the 1980s. This may be due to the fact that the proportionate area under irrigation increased in these districts due to the improvement of the irrigation supplies and exploitation of tubewell water during the 1970s. But, afterwards, the bad quality groundwater and the drainage problem led to increases in the CWA during the 1980s when compared to the 1970s and 1960s.

Table 46. Regression Results Relating the Farm Area and the Proportion of the Irrigated Farm Area with the Culturable Waste Area in the Sindh Province (1960-1990).

	Constant	DV72	DV80	DV90	LCICAT	LNCAICA72	LCICAT80	LNCICA90	LNAFAT	LNAFAT72	LANFAT80	LNAFAT90	Fcalc	Adj R^2	DF Total
Badin	-2.37 (0.578)								1.23 (0.20)				20.28	0.707	16
Dadu	-2.245 (0.402)			0.904 (0.526)	-0.810 (0.42)				1.103 (0.115)				36.131	0.76	33
Hyderabad	-3.336 (0.356)			1.39 (0.435)					1.395 (0.110)				80.55	0.83	32
Jaccobabad	-3.363 (0.311)	-3.817 (0.933)							1.399 (0.103)	0.864 (0.287)		0.763 (0.232)	64.64	0.88	32
Khairpur	-3.671 (0.147)	-0.823 (0.197)		- 0.548 (0.234)	-18.07 (2.762)			-65.06 (10.265)	1.277 (0.048)		-0.352 (0.075)	-0.753 (0.114)	225.64	0.979	34
Larkana	-4.030 (0.235)				-13.05 (5.514)				1.56 (0.10)	-0.461 (0.229)		-0.244 (0.127)	17.22	0.67	8
Naushehro Feroze	-1.861 (0.709)											0.999 (0.241)	96.622	0.916	35
Nawabshah	-3.53 (0.23)	-0.533 0.235	-2.156 (0.42)	0.946 (0.466)				-70.71 (10.04)	1.335 (0.06)		0.505 (0.13)	-1.16 (0.197)	119.48	0.963	32
Sanghar	-3.864 (0.422)	-1.793 (0.741)		1.305 (0.456)		-12.63 (5.63)			1.50 (0.13)				45.484	0.825	31
Shikarpur	-5.56 (0.399)			- 2.874 (0.644)					2.298 (0.151)		-0.505 (0.199)		143.45	0.968	14
Sukkur	-3.049 (0.186)	-2.142 (0.36)	-1.66 (0.58)		-3.093 (1.58)			-29.33 (5.69)	1.187 (0.057)	0.549 (0.115)	0.410 (0.113)		159.155	0.971	33
Tharparkar	-3.52 (0.467)		-1.086 (0.546)	4.014 (0.665)					1.54 (0.143)			-1.325 (0.253)	31.015	0.779	34
Thatta	-3.452 (0.324)	0.808 (0.368)	0.663 (0.368)	1.877 (0.381)					1.42 (0.07)			-0.416	87.914	0.91	34
Left Bank	-2.949 (0.270)	-1.587 (0.439)	-1.415 (0.395)	1.596 (0.336)					1.267 (0.087)	0.376 (0.140)	0.323 (0.128)	-0.462 (0.133)	121.036	0.787	227
Right Bank	-3.328 (0.252)		-0.671 (0.328)	1.091 (0.396)			5.226 (2.594)		1.459 (0.075)				98.426	0.762	152
Sindh	-3.082 (0.204)	-0.775 (0.245)	-1.106 (0.309)	1.418 (0.266)		-3.0 (1.258)			1.351 (0.062)		0.239 (0.098)	-0.454 (0.089)	181.56	0.769	380

LNACWA = Constant + DV72 + DV80 + DV90 + LnCICAT + LnCICAT72 + LnCICAT80 + LnCICAT90 + LnFAT + LnFAT72 + LnFAT80 + LnFAT90

At the overall Sindh level, the relationship between farm size and CWA remains the same during the 1980s and 1990s as in the 1970s because the coefficients for FAT80 and FAT90 are non-significant.

Regarding the partial effect of irrigation on CWA in Equation 8, it has been found that irrigation played a significant role in reducing the CWA in Dadu, Khairpur, Larkana and Sukkur during the 1960s (as the elasticity coefficient for irrigation is negative and significant at the 99 percent level of confidence in these districts). After the 1960s, there was not much improvement in the proportionate area under irrigation in Dadu and Larkana, which could play a significant role in decreasing the CWA. The technological improvements (as captured through the intercept and the intercept dummies) proved to be negative and statistically significant at the 99 percent level of confidence and there was no significant impact of technological change in the districts of Badin, Dadu, Hyderabad, Larkana and Shikarpur (as the intercept dummies for these districts were non-significant). In the case of Districts Nawabshah, Sukkur, Tharparkar and Thatta, the technological change has further reduced the culturable waste areas in these districts during 1980, but astonishingly, the technological change during the 1990s only helped in improving the situation in the districts of Khairpur and Shikarpur as the intercept dummies for these districts were negative and statistically significant at the 99 percent level of confidence. In the remaining districts, the technological change could not help to reduce the culturable waste areas on the farms in Sindh.

B. Spatial and Temporal Relationships of Cropping Intensity in Sindh

1) Farm Size and its Impact on Cropping Intensity in Sindh

A negative relationship between farm size and the cropping intensity was expected. In order to test this relationship, the log-linear Equation 9 (Section E, Chapter I) was estimated. In this equation, cropping intensity (CI) was used as the dependent variable and the farm size as independent; their post-1970s dummies were the explanatory variables in the equations. The regression coefficient estimates of Equation 9 are summarized in Table 47. All of the coefficients have the expected size and sign, proving the argument of an inverse relationship between farm size and cropping intensity. All equations, in each of the districts, are statistically significant at the 99 percent level of confidence. The explanatory power of the model (R2) is 0.42, 0.62, 0.85, 0.64, 0.89, 0.49, 0.92, 0.89, 0.30, 0.86, 0.66, 0.77, 0.52, 0.31 and 0.33 for the districts of Badin, Dadu, Hyderabad, Jaccobabad, Khairpur, Larkana, Nawabshah, Sanghar, Shikarpur, Sukkur, Tharparkar and Thatta, respectively. The explanatory powers of the model (R2) for the Left Bank, Right Bank and for overall Sindh were 0.52, 0,31 and 0.33, respectively. It is clear from the regression equations in Table 47 that the greater the farm size, the lower the cropping intensity. This inverse relationship persisted in almost all the districts beyond the Green Revolution period and has become less strong during the 1980s and 1990s in all the districts of the Sindh Province.

Table 47 Regression Results Relating the Farm Area with the Cropping Intensity in the Sindh Province (1960-1990).

Districts	Constant	DV72	DV80	DV90	LNAFAT	LNAFAT72	LNAFAT80	LNAFAT90	Fcalc	Adj R^2	DF Total
Badin	0.05* (0.21)			0.11* (0.03)					13.38	0.42	17
Dadu	0.35* (0.03)				-0.06* (0.01)	-0.04* (0.01)			30.57	0.62	35
Hyderabad	0.02* (0.03)	0.17* (0.42)	0.38* (0.42)	0.40* (0.42)	-0.08* (0.01)				54.37	0.86	35
Jaccobabad	0.54* (0.04)		0.11* (0.06)	0.11* (0.06)	-0.08* (0.01)	0.08* (0.01)	0.05* (0.02)	0.06* (0.02)	11.66	0.64	35
Khairpur	0.34* (0.02)		0.26* (0.04)	0.18* (0.02)	-0.05* (0.01)	-0.02* (0.01)	-0.05* (0.01)		60.80	0.89	35
Larkana	0.76* (0.13)				-0.40* (0.07)	0.27* (0.08)	0.31* (0.08)	0.32* (0.08)	9.40	0.49	35
N.Feroze	0.48* (0.02)							-0.05* (0.01)	111.20	0.93	8
Nawabshah	0.26* (0.02)		0.09* (0.04)	0.32* (0.04)	-0.11* (0.01)	0.02* (0.01)	0.07* (0.01)	0.04* (0.01)	70.48	0.92	35
Sanghar	0.13* (0.04)	0.24* (0.04)	0.41* (0.04)	0.45* (0.08)	-0.08* (0.01)		0.05* (0.02)		57.34	0.89	33
Shikarpur	0.65* (0.02)						-0.02* (0.01)		8.28	0.30	17
Sukkur	0.45* (0.02)		0.13* (0.03)	0.20* (0.42)	-0.08* (0.01)	0.04* (0.01)		0.04* (0.01)	47.27	0.87	35
Tharparkar	0.10* (0.02)			0.19* (0.03)	-0.05* (0.01)		0.04* (0.01)		23.92	0.66	35
Thatta	0.26* (0.03)	0.24* (0.05)	0.28* (0.05)		-0.10* (0.01)			0.10* (0.01)	30.54	0.77	35
Left Bank	0.19* (0.03)	0.09* (0.03)	0.21* (0.03)	0.26* (0.04)	-0.07* (0.01)			0.02* (0.01)	52.99	0.52	240
Right Bank	0.55* (0.04)				-0.17* (0.02)	0.09* (0.02)	0.13* (.02)	0.14* (0.02)	19.28	0.31	161
Sindh	0.36* (0.03)		0.10* (0.05)	0.13* (0.05)	-0.12* (0.01)	0.05* (0.01)	0.06* (0.02)	0.07* (0.02)	34.97	0.34	402

Note:

- The figures in parenthesis are the standard errors.
- Results are significant at 99 % confidence level.

The elasticity coefficients for the Left and the Right Bank areas show that as the farms become larger the cropping intensity will decrease. This relationship was stronger in the Right Bank area ($B1$ = -174) when compared to the Left Bank area ($B1$ = -0.068). In the Left Bank area, this relationship remained the same after the Green Revolution period (during the 1980s and 1990s), while in the Right Bank area the inverse relationship has weakened since the 1980s ($B1 + B3$ = -0.046) and continued into the 1990s ($B1 + B4$ = -0.035). The examination of the elasticity coefficients for the overall Sindh data revealed that this negative relationship was stronger (-0.055) during the 1980s when compared with (-0.048) the 1990s. Table 47 also showed a positive response of the improvement in the technology and the increase in the cropping intensity across all of the districts of the Sindh Province, since the intercept term in all of the intercept dummies in all the equations are positive and are statistically significant at the 99 percent level of confidence. The technological change increased the intercept from 0.23, 0.129 and 0.236 in Districts Hyderabad, Sanghar and Thatta during the 1960s to 0.307, 0.371 and 0.496, respectively, during the 1990s.

2) Irrigation Supplies and their Impact on Cropping Intensity in Sindh

To test the significance of the relationship between the cropping intensity and the availability of irrigation supplies, Equation 10 (Section E, Chapter I) was estimated by incorporating the proportionate area under irrigation per farm in the Sindh Province along with the farm size and intercept dummies. The summary of results from Equation 10 are given in Table 48, wherein the intercept term, as well as all the intercept dummies, are positive and statistically significant at the 99 percent level of confidence. This showed that technological advancements led to an increment in the cropping intensity in all of the districts. At the district level, the explanatory power of the model (Adjusted R2) ranges between 0.49 to 0.95. In the case of all the districts of Sindh during the1960s, all of the farm size (FAT) coefficients are statistically significant at the 99 percent level of confidence and have a negative sign. The estimated coefficients of the farm area during the 1970s, 1980s and 1990s suggest that the inverse relationship between farm area and cropping intensity has been weakened over time in all the districts, except the Jaccobabad and Sanghar Districts. In the case of the Left and Right Bank areas, Table 48 shows the existence of a similar relationship.

The irrigation coefficient showed a positive relationship with the cropping intensity for all the districts in the Sindh Province. During 1960 the irrigation coefficient was positive and significant at the 99 percent level of confidence in the districts of Badin, Dadu, Jaccobabad, Hyderabad, Khairpur, Nawabshah, and Shikarpur. This relationship continued in the districts of Hyderabad, Jaccobabad, and Shikarpur during the 1990s. This means that if irrigation supplies were increased, there will be a tendency to bring more area under cultivation, and thereby, reduce the unculturable waste areas in these districts, except in Dadu, Khairpur and Tharparkar, where this relationship was further augmented during the 1990s.

Table 48 Regression Results Relating the Farm Area and the Proportion of the Irrigated Farm Area with the Culturable Waste Area in the Sindh Province (1960-1990).

	Constant	DV72	DV80	DV90	LClaCAT	LNCAICA72	LCICAT80	LNCICA90	LNAFAT	LNAFAT72	LANFAT80	LNAFAT90	Fcalc	Adj R^2	DF Total
Badin	0.11* (0.02)				1.99* (0.42)				0.03* (0.01)				11.37	0.55	17
Dadu	0.39* (0.18)			0.19* (0.05)	0.23* (0.03)	0.83* (0.07)		1.06* (0.19)			-0.05* (0.01)	-0.04* (0.01)	46.14	0.89	35
Hyderabad	0.01* (0.04)	0.23* (0.05)	0.42* (0.05)	0.42* (0.04)	0.60* (0.33)				-0.06* (0.01)				47.51	0.87	35
Jaccobabad	0.43* (0.02)	0.20* (0.02)	0.25* (0.03)	0.24* (0.03)	1.10* (0.08)		-0.69* (0.35)				-0.03* (0.01)	-0.02* (0.01)	61.84	0.92	35
Khairpur	0.44* (0.02)	-0.08* (0.03)	0.13* (0.02)		2.57* (0.53)	-2.09* (0.69)	-1.43* (.57)	2.73* (1.32)	-0.06* (0.004)			0.08* (0.01)	98.14	0.96	35
Larkana	0.76* (0.13)								-0.40* (0.07)	0.27* (0.08)	0.31* (0.08)	0.32* (0.08)	9.40	0.49	35
N. Feroze	0.48* (0.02)											-0.05* (0.005)	111.20	0.93	8
Nawabshah	0.27* (0.02)			0.31* (0.02)	2.04* (0.30)	-2.31* (0.33)	-4.15* (0.43)		-0.05* (0.01)	-0.06* (0.01)			124.17	0.95	35
Sanghar	0.13* (0.04)	0.24* (0.04)	0.41* (0.40)	0.47* (0.07)					-0.09* (0.01)			0.51*	57.34	0.89	33
Shikarpur	0.58* (0.32)			0.12* (0.04)	3.56* (1.18)						-0.02* (0.01)	-0.02* (0.01)	7.00	0.57	17
Sukkur	0.46* (0.22)		0.12* (0.03)	0.18* (0.04)		1.44* (0.60)			-0.09* (0.01)	0.07* (0.02)		0.04* (0.01)	46.49	0.89	35
Tharparkar	0.11* (0.02)			0.20* (0.05)			0.09* (0.05)	0.11* (0.04)	-0.06* (0.01)		0.07* (0.02)	0.03* (0.02)	16.38	0.72	35
Thatta	0.26* (0.03)	0.24* (0.05)	0.28* (0.05)						-0.01* (0.01)			0.10* (0.01)	30.54	0.77	35
Left Bank	0.17* (0.03)	0.13* (0.03)	0.23* (0.03)	0.29* (0.04)		0.39* (0.20)	0.13* (0.54)	0.21* (0.05)	-0.06* (0.01)			0.02* (0.01)	38.81	0.56	240
Right Bank	0.58* (0.04)					1.37* (0.48)	1.27* (0.56)	1.54* (0.51)	-0.18* (0.02)	0.16* (0.03)	0.16* (0.03)	0.16* (0.02)	15.40	0.38	161
Sindh	0.36* (0.03)		0.10* (0.05)	0.14* (0.05)		0.70* (0.28)	0.24* (0.09)	0.87* (0.09)	-0.12* (0.01)	0.08* (0.02)	0.07* (0.02)	0.08* (0.02)	27.35	0.37	402

Note:
The figures in parenthesis are the standard errors.
* Results are significant at 99 % confidence level

C. Measurement of Inefficiency in the Cropping Intensity of Net Cultivated Farm Area in Sindh

The results from Tables 45 and 46 revealed that both, the intensive and extensive use of land was lower on the large farms when compared to small farms. In other words, as the farm size increases, both, intensive and extensive use of land decreases. Let us pose ourselves a question. What would happen if everybody used the land the way the small farmers are using it? Or, what if redistribution of land takes place? Whatever policy is implemented to fully utilize the land, at least the unirrigated area will be cultivated once and the irrigated area cultivated twice. If such a policy is followed, there is a need to know how much inefficiency exists in extensive and intensive farming at the aggregate and at the canal command level. On the basis of these assumptions, indices have been developed (indicated in Tables 49 - 55) that will help in identifying how much land is underutilized and how it is distributed among different farm categories in different regions.

In order to estimate the index of inefficiency, certain assumptions were considered that are reasonable within the limitations of the available data. For measuring the inefficiency in cropping intensity, irrigated areas (CAI) are assumed to have the potential for two crops and unirrigated areas (NSA) for at least one crop. As such, the minimum potential number of times a unit area of land is croppable (GCA) is equal to twice the net-irrigated area added to the unirrigated area. There is a possibility that a negative number might be obtained in certain cases because the unirrigated area may be cropped more than once and/or the irrigated areas may be cropped more than two times a year, thereby making GCA greater than the sum of the NSA and CAI.

Table 49 shows the results from the IIMI 1997-98 survey of the Sindh Province. Table 49 shows that, at the Sindh level, the measure of inefficiency across farm categories during 1998 was higher on the large farms at the canal command level, the large and medium farms in the canal commands of Jamrao, Nara, Khairpur East, Khairpur West, Lined Channel, Rice, Fuleli and Pinyari Canals. These results, when viewed in the context of the estimates of the inefficiency indices (Table 49), which are calculated from the 1997-98 Sindh survey data, confirm that the small farmers are the most efficient in the potential utilization of the farmlands. Table 49 also shows that the inefficiencies of the medium and large farmers in the canal commands of Khairpur East, Khairpur West, Lined Channel, Rice Canal, Fuleli and Pinyari Canals are not only much higher than the small farms in these canal commands, but that the medium and large farms in the canal commands of Rice, Desert, North West and Dadu Canals are comparatively more efficient. This shows that much scope exists to improve the efficiency of medium and large farms in the canal commands of Khairpur East, Khairpur West, Lined Channel, Rice, Fuleli and Pinyari Canals.

Table 49. Measures of Inefficiency in Cropping Intensity of Net Cultivated Area across Farm Size Groups and Canal Commands of the Sindh Province.

Canal Commands	Farm Size			Total
	Small	Medium	Large	
Begari	3.69	7.19	11.68	11.34
Dadu	14.48	9.30	10.36	11.14
Desert	7.59	3.38	4.65	4.57
Fuleli	18.55	33.28	34.62	34.22
Ghotki	2.83	6.27	34.83	27.96
Jamrao	8.67	22.55	41.80	40.76
Khairpur East	4.08	9.78	31.28	13.60
Khairpur West	10.01	14.32	30.36	22.58
Lined Channel	28.69	35.50	34.26	34.53
Nara	13.63	37.33	41.47	41.25
North West	5.64	6.26	17.23	14.96
Pinyari	11.52	39.14	50.80	48.66
Rice	0.57	3.59	6.53	5.32
Rohri	12.84	19.66	40.45	37.36
Sindh	6.86	14.77	30.22	28.03

$\frac{(CAI+NSA)}{(CAI+NSA-GCA)}$

Table 50. Percentage Distribution of Additional Croppable Land through Improvement in Cropping Intensity across Farm Size Groups and Canal Commands of the Sindh Province (1998).

Canal Commands	Farm Size			Total Area (ha)	Percentage Distribution in Canal Command
	Small	Medium	Large		
Begari	0.27	3.78	95.95	38641	2.72
Dadu	3.75	3.19	93.06	27275	1.92
Desert	0.87	5.71	93.42	7213	0.51
Fuleli	0.70	13.73	85.57	123391	8.70
Ghotki	0.25	4.78	94.97	102969	7.26
Khairpur East	4.00	46.94	49.05	29776	2.10
Khairpur We	3.60	24.23	72.17	44137	3.11
Lined Channel	0.37	24.12	75.52	76019	5.36
Nara	0.06	3.83	96.10	364088	25.66
North West	0.46	8.10	91.43	46254	3.26
Pinyari	0.16	12.94	86.90	157343	11.09
Rice	0.57	20.36	79.07	11174	0.79
Rohri	0.18	5.42	97.98	390534	27.53
Sindh	0.27	5.88	94.86	1418814	100.00

CAI+NSA-GCA

From the measures of inefficiency, it is observed that cropping intensities of the net cultivated area can be improved. The additional area, which can be cropped through the intensification of cropping is given in Table 50. At the aggregate level, the additional croppable land through the improvement in cropping intensity was determined to about 1.42 Mha; the major contribution being from the medium and large farm holdings.

D. Measurement of Inefficiency in Total Land Use in the Sindh Province

The analysis also computed the indices to measure the inefficiency in total land use by combining the inefficiency in cropping intensity with the culturable waste area (CWA). These indices have been computed at the Sindh and canal command levels by incorporating the CWA into the above inefficiency in cropping intensity (Tables 49 & 50). The indices show similar trends in the distribution of inefficiency in total land use among different farm categories as are reported in Tables 51 and 52 for the measures of inefficiency in cropping intensity and the additional net cultivated area in the Sindh Province.

Tables 51 & 52 show the indices computed for the percentage distribution of additional croppable land through improvement in culturable waste areas at the Sindh and canal command levels. For the Sindh Province, about 1.94 Mha of additional land can be brought under the croppable area through improvement in the culturable waste areas. Again, the major contributors are the medium and large farm holdings.

E. Cropping Potential of Culturable Waste Area in the Sindh Province

By using the above measures of inefficiency, the total land loss is computed at the Sindh and canal command levels (Table 52). The total increase in cropped area at the Sindh level, by making improvements in the cropping intensity and by bringing in the additional area from culturable waste lands, amounts to 1.94 Mha, which is about 56 percent of the total croppable area. Out of this potential recovery, 28 percent is from the improvement in cropping intensity and the remaining area comes from culturable wastes.

Table 51. Measures of Inefficiency in Total Land Use across Farm Size Groups and Canal Commands in the Sindh Province.

Canal Command	Farm Size			Total
	Small	Medium	Large	
Begari	5.21	10.91	24.60	23.73
Dadu	15.18	11.78	35.97	22.29
Desert	7.59	7.10	20.25	19.30
Fuleli	31.36	42.21	50.20	48.03
Ghotki	4.94	9.76	45.17	37.49
Jamrao	11.45	31.33	49.97	48.98
Khairpur East	6.12	16.23	31.28	17.97
Khairpur West	15.80	18.62	36.97	28.32
Lined Channel	33.38	50.48	52.92	52.31
Nara	15.69	39.99	48.29	47.90
North West	10.14	14.49	40.68	36.17
Pinyari	32.26	45.08	61.71	59.14
Rice	1.05	7.35	37.36	28.81
Rohri	12.84	22.98	48.27	45.10
Sindh	9.55	20.59	41.50	38.88

$$\frac{(CAI+NSA+CWA)}{(CAI+NSA+CWA-GCA)}$$

Table 52. Percentage Distribution of Additional Croppable Land through Improvement in the Culturable Waste Area across Canal Commands in different Farm Size Classes.

Canal Commands	Farm Size			Overall	All group Percentage Distribution
	Small	Medium	Large		
Begari	0.16	2.46	97.38	80861	4.16
Dadu	7.36	18.33	74.31	54575	2.81
Desert	0.18	2.5	97.33	30461	1.57
Fuleli	0.79	11.32	91.72	173188	8.91
Ghotki	0.29	5	94.71	138065	7.10
Khairpur East	4.41	60.33	35.26	39343	2.02
Khairpur We	4.49	24.48	71.68	55356	2.85
Lined Channel	0.22	21.47	78.31	115162	5.92
Nara	0.06	3.27	96.67	422784	21.74
North West	0.27	6.39	93.52	111833	5.75
Pinyari	0.38	10.81	88.81	191230	9.83
Rice	0.15	6.02	93.83	60511	3.11
Rohri	0.13	4.8	97.7	471442	24.24
Sindh	**0.24**	**5.39**	**95.17**	**1944812**	**100.00**

(CAI+NSA+CWA-GCA)

F. Additional Production Potential in the Canal Command Areas of Sindh

Tables 53 and 54 provide the estimates regarding the distribution of area under different crops with respect to the GCA in the Sindh Province. It shows that on the average, about 29, 24, 18 and 8 percent of the GCA, respectively, fall under the wheat, rice, cotton and the sugarcane crops in the Sindh Province. If this proportion of distribution is maintained, then, from Table 54, about 0.55 Mha will be cultivated under the wheat crop, 0.463 Mha will be cultivated under the rice crop and the average area under the cotton and the sugarcane crops will be 0.336 and 0.155 Mha, respectively. The major contribution is coming from the canal commands of the Rohri, Nara, and Ghotki Canals and Lined Channel, which are the major contributors in the area for the wheat crop.

Table 53. Percent Share of Major Crops in Total Cropped Area across different Canal Commands of the Sindh Province.

Canal Command	Cotton	Rice	Sugarcane	Wheat
Begari	.00	54.25	.00	27.91
Dadu	.81	46.07	6.11	32.23
Desert	.00	50.27	.00	33.66
Fuleli	1.30	37.55	27.41	13.51
Ghotki	42.72	4.16	2.27	43.72
Jamrao	31.17	.59	9.50	35.71
Khairpur East	30.37	4.25	4.96	38.50
Khairpur West	10.12	6.04	8.94	28.73
Lined Channel	2.49	29.79	39.52	14.25
Nara	37.79	1.06	4.34	34.98
North West	.52	57.45	.70	15.64
Pinyari	.00	40.09	34.38	11.26
Rice	.00	51.39	.00	15.70
Rohri	29.61	2.68	15.15	33.30
Sindh	17.71	24.45	8.16	28.98

Table 54. Potential Increment in Area under Major Crops (ha).

Canal Command	Cotton	Rice	Sugarcane	Wheat
Begari		43869		22564
Dadu	440	25143	3336	17588
Desert		15313		10253
Fuleli	2248	65035	47464	23389
Ghotki	58984	5742	3129	60366
Khairpur East	11950	1670	1953	15147
Khairpur West	5602	3345	4947	15902
Lined Channel	39334	927	8261	40744
Nara	10510	125960	167093	60239
North West	585	64244	780	17491
Pinyari		76657	65749	21528
Rice		31099		9503
Rohri	139611	12641	71403	157001
Sindh	**335839**	**463651**	**154740**	**549555**

In consideration of the existing average yields of the four major crops (Table 55), Table 56 estimates the potential productivity of these crops in the Sindh Province. It shows that by increasing the cropping intensity of the existing cultivated areas and by bringing the culturable waste under cultivation, the canal command areas of Sindh have the potential to produce 1.11 million metric tons of wheat, 1.66 million metric tons of rice, 0.579 million metric tons of cotton and 10.34 million metric tons of sugarcane.

Table 55. Existing Yields of Major Crops in Canal Commands of Sindh (1997-98) (ton/ha).

	Cotton	Rice	Sugarcane	Wheat
Begari	0	3.506	0	1.327
Dadu	0	3.944	61.997	1.926
Desert	0	3.764	0	1.348
Fuleli	1.778	3.284	62.208	1.835
Ghotki	1.663	2.688	77.187	2.105
Khairpur East	1.4	2.201	65.962	2.299
Khairpur We	1.051	3.188	56.261	2.022
Lined Channel	1.551	3.058	62.686	1.682
Nara	2.051	3.631	69.16	2.394
North West	0	3.617	50.223	1.478
Pinyari	0	2.495	68.419	2.097
Rice	0	4.399	0	1.209
Rohri	1.689	3.498	71.529	2.563
Sindh	**1.725**	**3.575**	**66.803**	**2.026**

Table 56. Potential Increment in Production of Major Crops in Canal Commands of Sindh (ton).

Canal Command	Cotton	Rice	Sugarcane	Wheat
Begari		153806		29943
Dadu		99165	206832	33875
Desert		57638		13821
Fuleli	3997	213574	2952625	42919
Ghotki	98091	15434	241499	127071
Khairpur East	16730	3677	128833	34822
Khairpur West	5888	10664	278337	32154
Lined Channel	61006	2834	517836	68532
Nara	21556	457361	11556133	144212
North West		232369	39151	25852
Pinyari		191258	4498449	45143
Rice		136805		11489
Rohri	235802	44220	5107355	402394
Sindh	**579448**	**1657553**	**10337101**	**1113398**

Based on the additional cropping potential mentioned above, the question arises as to why the farmers in the Sindh Province are unable to achieve this potential. Table 57 provides the reasons to this effect, wherein the most dominant constraint at the farm level is the reported scarcity of irrigation water. This constraint is more severe in all of the three farm categories in the Faisalabad District, where, on average, about 66 percent of the farmers reported shortages of irrigation water. The second major reason reported by about 20 percent of the reported farm holdings, is the incidence of salinity that depresses the cropping intensity on the farms. Another 10 percent of the farms reported some other reasons (waterlogging, sodicity, mechanical breakdown of tractor/tubewell, non-availability of credit, etc.) for maintaining fallow farm land.

In total, about 13 percent of the farms responded that they have a cropping intensity of about 200 percent and never kept the land fallow. Most of these respondents were small farmers who are located either on the head reaches of the watercourses, or have access to groundwater of good quality, which helps them to cultivate two crops per year.

VII RESOURCE PRODUCTIVITY IN THE SINDH PROVINCE

The regression models are used to estimate the resource productivity of the four major crops (wheat, cotton, rice and sugarcane) raised on the sample farms in the Sindh Province. The Cobb-Douglas production functions were developed and used for three types of data sets; (a) overall sample of all farms at the Sindh level, (b) the selected sample from the Left and the Right Banks of the Indus River and (c) the sample farms in each of the canal command levels, for each of the above-mentioned crops. The results are presented in Tables 57-60 for the major crops. The generation of these production functions was beset with specification problems since the true explanatory variables had remissions in their certainty. Also, the presence of some implicit/joint production factors, such as tubewell irrigation and farmyard manure, may not be fully explained by such analyses. However, in order to avoid the mis-specification bias due to high multicollinearity (Madala 1988), the inter-correlation amongst the explanatory variables was tested and no serious problem of multicollinearity was found.

A. Regression Results for the Wheat Crop

1) Production Function Estimation for Wheat in the Canal Commands in Sindh

The estimates of the regression equations relating the LNYLDWHT with the LNCOFERT, LNCOLAND, LNFSIZE, LNNOIRR and LNHOEING are given at the canal command levels in Table 57. All the equations are having a high explanatory power (adjusted R2), ranged between 0.61 in the regression equation for the Rice Canal command area to 0.99 in the Ghotki, Lined Channel and Rohri Canal command areas. In the Begari Canal command area, the regression equation is statistically significant at the 99 percent level of confidence and the regression variables explained the variation in the wheat productivity by 90 percent. The regression coefficients show that the unit increase in the LNCOFERT, LNCOLAND and LNNOIRR will increase the wheat productivity by 0.33, 0.52 and 0.40 percent, respectively. The LNFSIZE coefficient for the Begari Canal is statistically significant at the 99 percent level of confidence and has an inverse relationship with the wheat productivity on the farms located in the Begari Canal command area. The estimates of regression coefficients show that the maximum response from the LNCOFERT coefficient on the wheat productivity was seen in the farms located in the Fuleli Canal command area (0.88) when compared to regression coefficients for the farms located on the canal command areas of the Begari (0.33), Dadu (0.42), Desert (0.45), Ghotki (0.05), Jamrao (0.22), Khairpur E (0.16), Khairpur W (0.39), Lined Channel (0.46), North West (0.07), Pinyari (0.61) and Rohri Canals (0.40). In the case of the LNCOLAND coefficient, the regression coefficients ranged between 0.02 in the Ghotki command area to 0.91 in the Fuleli Canal command area. This shows that a unit increase in the cost of land preparation will increase the wheat productivity by 0.51, 0.14, 0.49, 0.29, 0.91, 0.49, 0.72, 0.30, 0.49, 0.84, 0.42, 0.26, 0.61 percent on the farms located in the Begari, Dadu, Desert, Fuleli, Ghotki, Jamrao, Khairpur E, Khairpur W, Lined Channel, North West, Pinyari, Rice and Rohri Canal command areas, respectively. The regression results show that the LNNOIRR coefficient is significant at the 99 percent level of confidence in the equations providing results from the Begari, Dadu, Ghotki, Jamrao, Khairpur E, Khairpur W, Northwest and Rice Canal command areas.

Table 57. Regression Results Relating the Wheat Productivity with Dependent Variables across Farm Areas in Sindh (1997-98).

	(Constant)	LNCOFERT	LNCOLAND	LNFSIZE	LNNOIRR	LNHOEING	Adj R^2	F-Calc	DF
Begari	1.677	0.333	0.517	-0.964	0.403		0.907	283.314	116
	(0.341)	(0.066)	(0.067)	(0.324)	(0.103)				
Dadu	3.081	0.429	0.140		0.256		0.844	44.431	24
	(0.761)	(0.113)	(0.037)		(0.143)				
Desert	0.876	0.459	0.496				0.911	242.181	47
	(0.374)	(0.077)	(0.077)						
Fuleli	0.256	0.882	0.291				0.974	836.485	44
	(0.210)	(0.039)	(0.083)						
Ghotki	0.231	0.052	0.918	-0.203	0.134		0.985	2946.808	179
	(0.096)	(0.021)	(0.028)	(0.088)	(0.029)				
Jamrao	1.600	0.223	0.491	-0.975	0.589		0.937	466.337	125
	(0.276)	(0.108)	(0.121)	(0.272)	(0.104)				
Khairpur East	0.802	0.161	0.729		0.181		0.894	210.013	74
	(0.393)	(0.040)	(0.067)		(0.089)				
Khairpur West	1.787	0.398	0.305	-0.307	0.180		0.951	227.094	47
	(0.522)	(0.118)	(0.108)	(0.165)	(0.073)				
Lined Channel	0.006	0.465	0.499				0.996	4145.822	35
	(0.080)	(0.152)	(0.159)						
North West	0.643	0.073	0.849		0.137	0.106	0.936	373.107	101
	(0.251)	(0.030)	(0.048)		(0.055)	(0.061)			
Pinyari	-0.412	0.613	0.428				0.937	90.413	12
	(0.678)	(0.144)	(0.173)						
Rice	4.917		0.260	-0.021	0.433		0.609	29.594	55
	(0.462)		(0.067)	(0.287)	(0.136)				
Rohri	0.326	0.402	0.615	-0.381			0.987	6524.606	248
	(0.079)	(0.041)	(0.044)	(0.093)					
Right Bank	1.658	0.140	0.689	-0.540		0.297	0.876	612.602	347
	(0.191)	(0.025)	(0.029)	(0.169)		(0.055)			
Left Bank	0.489	0.158	0.769	-0.350	0.199		0.973	7981.253	871
	(0.062)	(0.018)	(0.022)	(0.059)	(0.024)				
Sindh	0.767	0.138	0.772	-0.312	0.181		0.943	5003.083	1219
	(0.074)	(0.014)	(0.016)	(0.068)	(0.024)				

Note: Figures in parenthesis are the standard errors.

These results show that a one percent increase in the LNNOIRR will increase the productivity of wheat by 0.40, 0.25, 0.13, 0.58, 0.18, 0.18, 0.13 and 0.43, respectively, on the farms located in the Begari, Dadu, Ghotki, Jamrao, Khairpur E, Khairpur W, North West and Rice Canal command areas. The regression results for the LNFSIZE coefficient show that it is negative and statistically significant at the 99 percent level of confidence on the farms located in the canal command areas of Begari, Ghotki, Jamrao, Khairpur W, Rice and Rohri Canals. The LNFSIZE coefficient shows that a one percent increase in the farm size lowers the wheat productivity by 0.96, 0.20, 0.97, 0.30, 0.02, and 0.38 percent, respectively, on the farms located in the canal command areas of Begari, Ghotki, Jamrao, Khairpur W, Rice and Rohri Canals.

2) Production Function Estimation for Wheat on the Left and Right Banks of the Indus River

The regression results for the sample farms from the Right and the Left Banks of the Indus River are given in Table 57. The results showed that LNCOFERT, LNCOLAND and LNFSIZE were significant at the 99 percent level of confidence on both, the Right and the Left Banks of the Indus River in the Sindh Province. The coefficient for hoeing LNHOEING is statistically significant at the 99 percent level of confidence in the regression equation for the Right Bank only. The explained variation (shown by the Adjusted R^2) in the models is about 0.87 and 0.97 for the sample farms on the Right and Left Bank areas, respectively. The coefficients for LNWEDING and LNNOIRR were not significant for the farms on the Right Bank. On the Right Bank farms, a unitary increase in the LNCOFERT and LNCOLAND increases the wheat production on the farm by 0.14 and 0.69 percent, respectively. While, a one percent increase in the LNCOFERT and LNCOLAND in the Left Bank area increases the wheat production by 0.16 and 0.77 percent, respectively. In the case of the LNFSIZE coefficient it has a negative sign and the inverse relationship between farm size and wheat productivity is stronger (-0.54) on the sample farms located on the Right Bank when compared to the Left Bank area (-0.35). This means that if the farm size increases by one percent the wheat productivity will decrease by 0.54 percent on the Right Bank, when compared to a 0.35 percent decline in wheat productivity on the farms located on the Left Bank area. The LNNOIRR coefficient shows that in the case of the farms located in the Left Bank area, a unit increase in the irrigation will increase the wheat production by 0.19 percent, while on the Left Bank area the LNNOIRR has no significant impact on the wheat productivity.

3) Production Function Estimation for Wheat in the Sindh Province

The regression results for the cumulative sample information are summarized in Table 57. The Cobb-Douglas model for wheat contains six independent variables, i.e. land preparation cost (LNCOLAND), fertilizer cost (LNCOFERT), farm size (LNFSIZE), irrigation number (LNNOIRR), weedicide cost (LNWEEDC), and the number of hoeing (LNHOEING); the dependent variable was the average yield of wheat per farm (LNYLDWHT). The overall equation, as well as the explanatory variables, were significant at the 99 percent level of confidence (R^2 = 0.94). The estimated coefficients showed that irrigation, cost of land preparation, farm size and fertilizer costs were the main source of variation in the wheat production in the Sindh Province.

The elasticity coefficients showed that a one percent increase in the (LNCOLAND), LNCOFERT, and LNNOIRR augmented the wheat production by 0.77 percent, 0.14 percent and 0.18 percent, respectively. The coefficient for the farm size was also statistically significant at the 99 percent level of confidence and has the negative sign, which shows that a one percent increase in the farm size reduces the wheat production by 0.31 percent. The sum of the elasticity coefficients (0.77) showed decreasing returns to scale for wheat production in Sindh. The regression results, once again, confirmed the existence of the inverse farm size and productivity relationship in the Sindh Province even during 1997-98.

The most plausible reason for the low productivity of the LNYLDWHT is that on the majority of the farms the agriculture is done by the *Haris* (tenants), who use the traditional methods of ploughing through bullocks. They used the maximum of their efforts to plough the fields in the best possible way, which may be one of the reasons for a high coefficient of LNCOLAND. But, they reported having no access to modern equipment and machinery to plough their fields according to the required numbers and ways, which may have resulted in an overall low wheat yield per farm in the Sindh Province. The productivity coefficients for the LNCOFERT and LNNOIRR were also less due to modest applications of these inputs for two reasons: either, the required fertilizer/irrigation was not available in a sufficient quantity at the time of application, or if available, due to the shortage of the irrigation water/ credit available with the farmers, the farmers did not apply those fertilizer inputs in the required quantity. The coefficients for the hoeing (LNHOEING) and weeding (LNWEDING) came out to be non-significant, showing that hoeing and weeding activities do not significantly affect the wheat yields on the sample farms in the Sindh Province.

B. Regression Results for the Cotton Crop

1) Production Function Estimation for Cotton at the Canal Command Level

The cotton crop is only reported by the farms located on the Left Bank of the river Indus in the Sindh Province. The farm areas report that cotton production includes the canal command areas of the Fuleli, Ghotki, Jamrao, Khairpur E, Khairpur W, Lined Channel, Nara and the Rohri Canal command areas. The Regression results for the cotton crop at these canal command areas are shown in Table 58. In the case of the regression results for the farms located in the Fuleli Canal, only the coefficient for LNCOFERT came out to be statistically significant at the 99 percent level of confidence with an explanatory power of 0.98. The LNCOFERT coefficient for Jamrao, Khairpur W, Lined Channel and the Rohri Canal are statistically significant at the 99 percent level of confidence and have the values 0.08, 0.76, 0.73, and 0.32, respectively. The coefficient for LNCOLAND came out to be significant at the 99 percent level of confidence only for the farms located at the Ghotki, Jamrao, and Nara Canal command areas, and have a value of 0.28, 0.08 and 0.38, respectively. This shows that a one percent increase in the investment on land preparation will increase the cotton production by 0.28, 0.08 and 0.38 percent in the Ghotki, Jamrao and Nara Canal command areas, respectively. Contrary to the LNFSIZE coefficient in the wheat crop, the LNFSIZE in the cotton production is non-significant in the regression equations, except in the case of the Rohri Canal, where it is statistically significant at the 99 percent level of confidence and has a positive relationship with the cotton productivity. It shows that a one percent increase in the farm size on the cotton producing farms located in the Rohri Canal area experience increases in cotton productivity by 0.53 percent. Table 58 shows that the coefficient for LNNOIRR was statistically significant at the 99 percent level of confidence in the regression equations for the Ghotki, Jamrao, Khairpur E, Nara and Rohri Canal command areas.

Table 58. Regression Results Relating the Cotton Productivity with Dependent Variables across Farm Areas in the Sindh Province (1997-98).

	(Constant)	LNCOFERT	LNCOLAND	LNFSIZE	LNNOIRR	LNWEDIN	LNCOPP	Adj R2	F-Cala	DF Total
Fuleli	0.249	0.903						0.983	294.76	5
	0.459	0.053								
Ghotki	0.350		0.285		0.115	0.089	0.553	0.890	313.95	155
	0.409		0.074		0.048	0.040	0.076			
Jamrao	1.648	0.082	0.083		0.288		0.637	0.925	347.43	112
	0.429	0.037	0.046		0.075		0.069			
Khairpur East	5.916				0.962			0.882	239.31	32
	0.153				0.062					
Khairpur West	1.169	0.746						0.740	40.77	14
	1.006	0.117								
Lined Channel	8.752	0.737				0.079	0.485	0.904	25.98	8
	2.029	0.209				0.038	0.024			
Nara	1.032		0.387		0.267		0.343	0.948	605.61	99
	0.595		0.110		0.098		0.109			
Rohri	1.971	0.320		0.053	0.261		0.295	0.910	519.95	205
	0.358	0.062		0.031	0.051		0.055			
Left Bank	2.159	0.044	0.066	0.060	0.284		0.470	0.903	1189.90	637
Sindh	0.184	0.022	0.031	0.018	0.029		0.029			

Note: The figures in parenthesis are the standard errors.

The table shows that a unit increase in the LNNOIRR will increase the cotton productivity by 0.11, 0.28, 0.96, 0.27 and 0.26 for the farms located in the Ghotki, Jamrao, Khairpur E, Nara and Rohri Canal command areas, respectively. Table 58 shows that the regression coefficients were only statistically significant at the 99 percent level of confidence for the Ghotki Canal and Lined Channel, and have the values of 0.09 and 0.79, respectively, in the cases of farms raising cotton. The variable for the cost on plant protection (LNCOPP) came out to be statistically significant in the regression equations, depicting regression results from the canal command areas of the Ghotki, Jamrao, Lined Channel, Nara and Rohri Canal command areas. The LNCOPP coefficient shows that a one percent increase in the investment on the plant protection measures in the cotton crop increases the cotton production by 0.55, 0.63, 0.48, 0.34 and 0.29 percent on the cotton producing farms in the canal command areas of the Ghotki, Jamrao, Lined Channel, Nara and Rohri Canal.

2) Production Function Estimation for Cotton in the Left Bank of the Indus River in the Sindh Province

The regression equation for the production function relating the LNYLDCOT and the dependent variables for the sample farms raising cotton in the Sindh Province is given in Table 58. The overall model is statistically significant at the 99 the percent level of confidence. The value of the adjusted R^2 reveals that the included variables explain about 90 percent of the variation in the model. All the coefficients in the model have the expected sign and the magnitude, and are statistically significant at the 99 percent level of confidence, except the LNWEDING, which turns out to be non-significant. The LNCOPP coefficient has a positive sign and shows that a one percent increase in the expenditure on insect pest control increases the production of the cotton crop by 0.47 percent. Contrary to Chaudhary[4] (1997), the LNCOLAND coefficient depicts that a one percent increase in the cost of land preparation increases the cotton yield only by 0.06 percent. The LNNOIRR shows that a unit number of irrigation increases the yield of cotton by 0.28 percent. Dinar et. al (1986) and Bajwa et. al (1992) have also explained the harmful effects of the bad quality groundwater when used for irrigation. Contrary to the wheat crop, the LNFSIZE coefficient in this case shows a positive relationship between the farm size and the cotton production. It shows that a unit increase in the farm area will increase the cotton production by 0.06 percent. The sum of the regression coefficients comes out to be 0.92, depicting that decreasing returns to scale in cotton production prevails on the sample farms in the Sindh Province.

C. Regression Results for the Rice Crop

1) Production Function Estimation for Rice in the Canal Commands in Sindh

The results of the Cobb-Douglas production functions for sample farms in the 12 canal commands on the Left and the Right Banks of the Indus River in the Sindh Province are summarized in Table 59. Six independent variables, LNCOFERT, LNCOLAND, LNFSIZE, LNNOIRR, LNHOEING and LNWEEDING were used to evaluate their impact on the productivity of the rice crop. In the case of rice growing sample farm areas in the Begari Canal command, the coefficients for, LNCOFERT, LNCOLAND, LNFSIZE, LNHOEING and LNWEEDING were significant at the 99 percent level of confidence, respectively. From amongst the significant regression coefficients from the Begari Canal command area, LNCOLAND had the highest value of 0.67 in comparison to LNCOFERT (0.11), LNHOEING (0.21) and LNWEDING (0.115). The coefficient for farm size shows a negative relationship between farm size and rice production on the sample farms in the Begari Canal command area. The adjusted R^2 shows that about 98 percent of the variation in the regression equation for rice production in the Begari Canal command area is explained by the independent variables included in the model.

In the case of the regression equation for the rice farms on the Dadu Canal command area, the value of adjusted R2 is 0.84. The variables for LNCOFERT, LNCOLAND and LNWEDING coefficients came out to be statistically significant at the 99 percent level of confidence. These coefficients show that a one percent increase in the investment on LNCOFERT, LNCOLAND and LNWEDING will increase the rice production by 0.311, 0.43, 0.34 percent, respectively. In the case of the regression equation for the rice farms on the Desert Canal command area, the value of adjusted R2 is 0.98. The variables for LNCOFERT and LNCOLAND coefficients came out to be statistically significant at the 99 percent level of confidence. These coefficients show that a one percent increase in the

[4] Chaudhary M.M. (1997), "Cultivation of cotton in furrows" Agrevo Pakistan Ltd.

Table 59. Regression Results Relating the Rice Productivity with Dependent Variables across Farm Areas in the Sindh Province (1997-98).

	(Constant)	LNCOFERT	LNCOLAND	LNFSIZE	LNNOIRR	LNHOEING	LNWEDIN	Adj R2	F-Cala	DF Total
Begari	0.430	0.111	0.678	-0.334		0.210	0.115	0.986	2195.81	160
	(0.108)	(0.040)	(0.043)	(0.097)		(0.119)	(0.045)			
Dadu	0.394	0.311	0.430				0.345	0.847	48.99	26
	(0.712)	(0.125)	(0.123)				(0.163)			
Desert	0.285	0.3612	0.2311					0.980	2914.93	60
	(0.181)	(0.019)	(0.091)							
Fuleli	1.508	0.381	0.455	0.391				0.869	135.89	61
	(0.511)	(0.108)	(0.126)	(0.233)						
Ghotki	2.331	0.383	0.398					0.737	26.23	18
	(0.823)	(0.122)	(0.129)							
Jamrao	1.328		0.897					0.886	47.41	6
	(1.180)		(0.130)							
Khairpur Eas										
Khairpur We	3.199	0.433			0.518			0.909	51.00	10
	(1.181)	(0.208)			(0.198)					
Lined Channel	0.011	0.396	0.575		0.164		0.171	0.997	3810.96	42
	(0.060)	(0.137)	(0.150)		(0.075)		(0.045)			
North West	0.551	0.770	0.241					0.938	1427.67	190
	(0.177)	(0.063)	(0.066)							
Pinyari		0.195	0.697					0.918	245.76	22
		(0.057)	(0.066)							
Rice	6.121	0.277		1.170	0.091		0.146	0.737	72.50	102
	(0.448)	(0.058)		(0.205)	(0.033)		(0.066)			
Rohri	0.465		1.069	-0.595			0.602	0.995	2446.09	38
	(0.143)		(0.014)	(0.177)			(0.120)			
Right Bank	0.694	0.487	0.514	-0.277	0.069			0.949	2537.11	542
	(0.097)	(0.035)	(0.037)	(0.074)	(0.019)					
Left Bank	0.219	0.247	0.737					0.970	3488.73	218
	(0.098)	(0.036)	(0.037)							
Sindh	0.594	0.405	0.596	-0.340	0.089			0.956		761
	(0.078)	(0.026)	(0.028)	(0.065)	(0.018)					

Note: The figures in parenthesis are the standard errors.

investment on LNCOFERT and LNCOLAND will increase the rice production by 0.3612 and 0.2311 percent, respectively.

In the case of the remaining regression equations for other canal command areas, the value of the adjusted R^2, from 0.73 in the case of the Fuleli and the Rice Canals to 0.99 in the case of the regression equation for the Lined Channel command area. The LNCOFERT coefficient was statistically significant at the 99 percent level of confidence in the regression equations for the canal command areas of Fuleli, Ghotki, Khairpur West, Lined Channel, Pinyari and Rice Canals. The LNCOFERT coefficients in these equations are 0.38, 0.38, 0.433, 0.396, 0.77, 0.19, and 0.277 for the canal commands of Fuleli, Ghotki, Khairpur West, Lined Channel, Pinyari and Rice Canals, respectively. The LNCOLAND coefficient was statistically significant at the 99 percent level of confidence in the regression equations for the canal command areas of the Fuleli, Ghotki, Jamrao, Lined Channel, North West, Pinyari and Rohri Canals. The LNCOLAND coefficients in these equations are 0.455, 0.398, 0.897, 0.575, 0.241, 0.697 and 0.697 for the canal command areas of the Fuleli, Ghotki, Jamrao, Lined Channel, Northwest, Pinyari and Rohri Canals. For the respective farm size differentiation in canal commands, the farm size and productivity relationship was negative and statistically significant at the 99 percent level of confidence in the canal commands of Begari (-0.334), and Rohri Canal (-0.595) areas. A positive and statistically significant (at the 99 percent level of confidence) relationship is observed in the case of the Fuleli (0.391) and the Rice Canal (1.17) command areas. The coefficient for the irrigation came out to be statistically significant at the 99 percent level of confidence only in the regression equations for the canal command areas of Khairpur West (0.518), Lined Channel (0.164) and Rice Canal areas (0.091). The coefficient for weeding was only significant in the canal command areas of the Begari, Dadu, Lined Channel, Rice and Rohri Canal areas. The estimated coefficients show that a unit increase in the expenditure on weeding increases the rice production by 0.115, 0.345, 0.171, 0.146 and 0.602 percent in the canal command areas of the Begari, Dadu, Lined Channel, Rice and Rohri Canal areas, respectively.

2) Production Function Estimation for Rice in the Left Bank of the Indus River in the Sindh Province

Table 59 shows that in the case of the regression equations for the pooled data of rice farms on the Right and the Left Banks of the Indus River in the Sindh Province, the explained variations in the dependent variables came out to be 0.949 and 0.97, respectively. In the case of the Left Bank, only two regression coefficients, LNCOFERT and LNCOLAND, turns out to be statistically significant at the 99 percent level of confidence. These coefficients show that a one-unit increase in the expenditure on the fertilizer and land preparation will increase the rice production on the sample farms by 0.24 and 0.73 percent, respectively. Once again, similar to the results of Mustafa (1991) and Ali (1989), the sum of production elasticities showed that decreasing returns to scale prevail in the rice production on the farms in the Sindh Province ($b_1+b_2 = 0.97$). In the case of the Right Bank, the coefficients for LNCOFERT, LNCOLAND and LNNOIRR came out to be statistically significant at the 99 percent level of confidence. These coefficients show that a one-unit increase in the respective variable will increase the rice production on the sample farms by 0.48, 0.51 and 0.069 percent, respectively. The LNFSIZE coefficient shows a negative and statistically significant relationship prevailing on the Right Bank of the river Indus. It shows that a one percent increase in the farm size leads to a decline in the productivity of rice, by 0.277 percent.

3) Production Function Estimation for Rice in the Sindh Province

The regression equation in Table 59 shows the result from the pooled data for sample farms growing rice in the Sindh Province. The value of the adjusted R^2 is 0.95, which shows that 95 percent of the variation in the rice production is captured by the included variables in the equation. The LNCOFERT, LNCOLAND, LNFSIZE and LNNOIRR turn out to be statistically significant at the 99 percent level of confidence. The equation shows that a one percent increase in the LNCOFERT, LNCOLAND and LNNOIRR results in the 0.405, 0.596 and 0.89 percent increase in the rice production, respectively. The LNFSIZE coefficient once again showed a negative relationship with farm size and rice productivity. It shows that a one percent increase in the farm size leads to a reduction in the rice yield by 0.34 percent.

D Regression Results for the Sugarcane Crop

1) Production Function Estimation for Sugarcane in the Canal Commands in Sindh

Table 60 presents the regression estimates for equations from the sample farms growing sugarcane in different canal commands of the Indus River in the Sindh Province. Overall, the equations are statistically significant at the 99 percent level of confidence. The adjusted R^2 for the regression equations are 0.99, 0.917, 0.91, 0.96, 0.80, 0.86, 0.92, 0.92, 0.83, 0.96 and 0.94 for the canal commands of the Dadu, Fuleli, Ghotki, Jamrao, Khairpur (E), Khairpur (W), Lined Channel, Nara, North West, Pinyari and Rohri Canals, respectively. The LNCOFERT coefficient was statistically significant at the 99 percent level of confidence in the regression equations for the canal commands of the Dadu, Fuleli, Jamrao, Khairpur (E), Khairpur (W), Lined Channel, Nara, North West, Pinyari and Rohri Canals. The LNCOFERT coefficient has the values of 0.95, 0.294, 0.711, 0.63, 0.59, 0.42, 0.15, 0.911, 0.523, and 0.653 for these canal commands, respectively. This means that a one percent increase in the expenditure on fertilizer increases the sugarcane production on the sample farms in the Dadu, Fuleli, Jamrao, Khairpur (E), Khairpur (W), Lined Channel, Nara, North West, Pinyari and Rohri Canals by 0.95, 0.294, 0.711, 0.63, 0.59, 0.42, 0.15, 0.911, 0.523 and 0.653 percent, respectively. The regression results show that the LNCOLAND is statistically significant in the regression equations for the canal command areas of the Dadu, Fuleli, Ghotki, Lined Channel, Nara and Pinyari Canal command areas. The estimated regression coefficients show that a unit increase in the cost of land preparation increases the sugarcane production by 0.06, 0.87, 0.38, 0.7 and 0.26 percent, respectively, in the canal command areas of the Fuleli, Ghotki, Lined Channel, Nara and Pinyari Canals. In the case of the Dadu Canal command area, the regression LNCOLAND coefficient has a negative sign (-0.58) and is statistically significant at the 99 percent level of confidence. Table 60 shows that the LNNOIRR coefficient is statistically significant at the 99 percent level of confidence in the regression equations for the canal commands of the Dadu, Fuleli, Jamrao and Rohri Canal commands. The regression coefficients have the values of 0.256, 0.491, 0.266 and 0.315 for the canal commands of the Dadu, Fuleli, Jamrao and Rohri Canal commands, respectively. The LNCOPP coefficient is statistically significant at the 95 percent level of confidence for the regression equation in the Pinyari Canal command only, and has a value of 0.08. The LNHOEING coefficient is significant at the 99 percent level of confidence in the canal command area of Khairpur East and the Lined Channel and has the values of 0.067 and 0.214, respectively. The coefficient for LNWEEDING turns out to be significant in the regression equations for the canal commands of the Dadu, Khairpur East and Pinyari Canal command areas. The respective values of the regression coefficients turn out to be 0.48, -70 and 0.33 in the canal commands of the Dadu, Khairpur East and Pinyari Canal command areas.

Table 60. Regression Results Relating the Sugarcane Productivity with Dependent Variables across Farm Areas in the Sindh Province (1997-98).

	Constant	LNCOFERT	LNCOLAND	LNFSIZE	LNNOIRR	LNCOPP	LNHOEING	LNWEDIN	Adj R2	F-Cala	DF Total
Dadu	6.979	0.950	-0.583	-0.010	0.256			0.486	0.997	424.70	7
	(1.052)	(0.105)	(0.139)	(0.003)	(0.049)			(0.141)			
Fuleli	6.738	0.294	0.065	0.000	0.491				0.917	142.07	51
	(0.551)	(0.088)	(0.029)	(0.000)	(0.070)						
Ghotki	4.518		0.871						0.911	195.65	19
	(0.580)		(0.062)								
Jamrao	4.115	0.711			0.266				0.960	681.32	56
	(0.536)	(0.089)			(0.090)						
Khairpur East	5.357	0.630					0.679	-0.709	0.800	25.053	18
	(1.637)	(0.195)					(0.146)	(0.391)			
Khairpur West	2.204	0.590							0.860	105.75	17
	(0.883)	(0.102)									
Lined Channel	4.012	0.424	0.388				0.214		0.929	228.00	52
	(0.822)	(0.173)	(0.168)				(0.096)				
Nara	3.719	0.153	0.771						0.925	185.62	30
	(0.466)	(0.055)	(0.077)								
North West	3.590	0.911							0.834	26.089	5
	(1.679)	(0.178)									
Pinyari	4.403	0.523	0.268	0.000		0.080		0.334	0.963	100.37	19
	(0.799)	(0.129)	(0.112)	(0.000)		(0.036)		(0.087)			
Rohri	4.752	0.653			0.315				0.947	1310.5	146
	(0.357)	(0.056)			(0.055)						
Right Bank	4.587	0.670			0.329				0.957	146.54	13
	(0.842)	(0.126)			(0.108)						
Left Bank	6.688	0.279	0.057	0.197	0.556				0.888	828.12	416
	(0.184)	(0.029)	(0.014)	(0.092)	(0.032)						
Sindh	6.670	0.282	0.058	0.186	0.553				0.890	868.99	430
	(0.181)	(0.028)	(0.014)	(0.089)	(0.032)						

Note: The figures in parenthesis are the standard errors.

2) Production Function Estimation for Sugarcane on the Left and Right Banks of the Indus River

Table 60 shows the regression equations for the pooled data from the sample sugarcane farms on the Left and the Right Banks of the Indus River in the Sindh Province. The explained variation of the included variables in both equations is 95 and 89 percent for the Right and Left Bank areas, respectively. On the Right Bank of the Indus River only, two coefficients turn out to be significant at the 99 percent level of confidence, and have the values of 0.67 and 0. 329 for LNCOFERT and LNNOIRR, respectively. In the case of the Left Bank of the Indus River, the respective values of the regression coefficients are 0.279, 0.057, 0.197 and 0.556 for LNCOFERT, LNCOLAND, LNFSIZE and LNNOIRR.

3 Production Function Estimation for Sugarcane in the Sindh Province

The regression equation for the overall Sindh Province in Table 60 shows the adjusted R2 of the equation is 0.89. The statistically-significant coefficients include LNCOFERT, LNCOLAND, LNFSIZE and LNNOIRR, and have the values of 0.28, 0.058, 0.186 and 0.553, respectively. This means that a unit increase in any of the independent variables increases the sugarcane production by 0.28, 0.058, 0.186 and 0.553 percent, respectively. Similar to the Left Bank for overall the Sindh Province data, the regression equation shows a positive relationship with the farm size and the sugarcane production.

VIII COST OF PRODUCTION AND RETURNS FROM MAJOR CROPS IN THE SINDH PROVINCE (1997-98)

Tables 61-64 show the estimates of the variable cost of production, total income, gross margin/ ha, gross margin/M^3 of water, and gross margin/ man day of labor, from the production of wheat, cotton, rice and sugarcane on sample farms in different canal commands of Sindh (the details are given in Appendices B –E).

A. Cost of Production and Returns from the Wheat Crop

Table 61 depicts the cumulative variable cost of production, total income, gross margin/ ha, gross margin/M3 of water, and gross margin/ man day of labor, from the production of wheat on the sample farms in Sindh. This cost of production takes into consideration the SI and SII soil classes on the farm (the detailed cost of production for wheat production across different canal commands is annexed in Tables B1-B14). The return from crops depends not only on soil suitability, but other factors also, like water scarcity, diseases and the inputs used, which may also affect the crop productivity. Table 61 shows that the gross returns from the wheat crop raised on the SI soils in the canal commands of the Sindh Province ranged from Rs. 8,959/ha in the Rice Canal command area to Rs 16,821/ha in the Fuleli Canal command area. In the case of the farm samples having the SII soils types, the gross returns range from Rs 8,470/ha in the Rice Canal command area to Rs. 16,650 in the command area of the Rohri Canal. The total variable cost (for providing inputs in the farms having SI soils) for raising wheat on the sample farms ranges from Rs. 5,093/ha in the Rice Canal to Rs. 11,191/ha in the Fuleli Canal command area. The net returns from the wheat crop on the sample farms in the S-1 soils ranged from Rs. 1,926/ha in the Lined Channel command area to Rs. 8,544/ha in the Rohri Canal command area. Table 61 shows the net returns from the wheat crop production on the sample farms having the S-II soil type, ranging from Rs. 2,627/ha in the Rice Canal command area to Rs. 7,102/ha in the Rohri canal command area. The gross Margin/M3 of water was the highest on the sample farms having the S-1 soils in the Rice Canal command area. In the case of the sample farms having the soil S-II, the gross margin /M3 was the highest (Rs 6.91) on the farms that produce wheat in the canal command of the Khairpur East Canal. Table 61 also shows the gross margin per unit of labor on the sample farms having the S-1 soil category ranging from Rs. 160/man/day in the canal command area of the Lined Channel to Rs. 717 in the command area of the North West Canal. Table 61 also shows that the return from the wheat crop decreases as the land class is switched from SI to SII in all the canal commands of Sindh, except in the Khairpur East, Jamrao, and Lined Canal commands.

Figure 6. Total Output, Total Cost and Gross Margins from the Wheat Crop (Rs/ha).

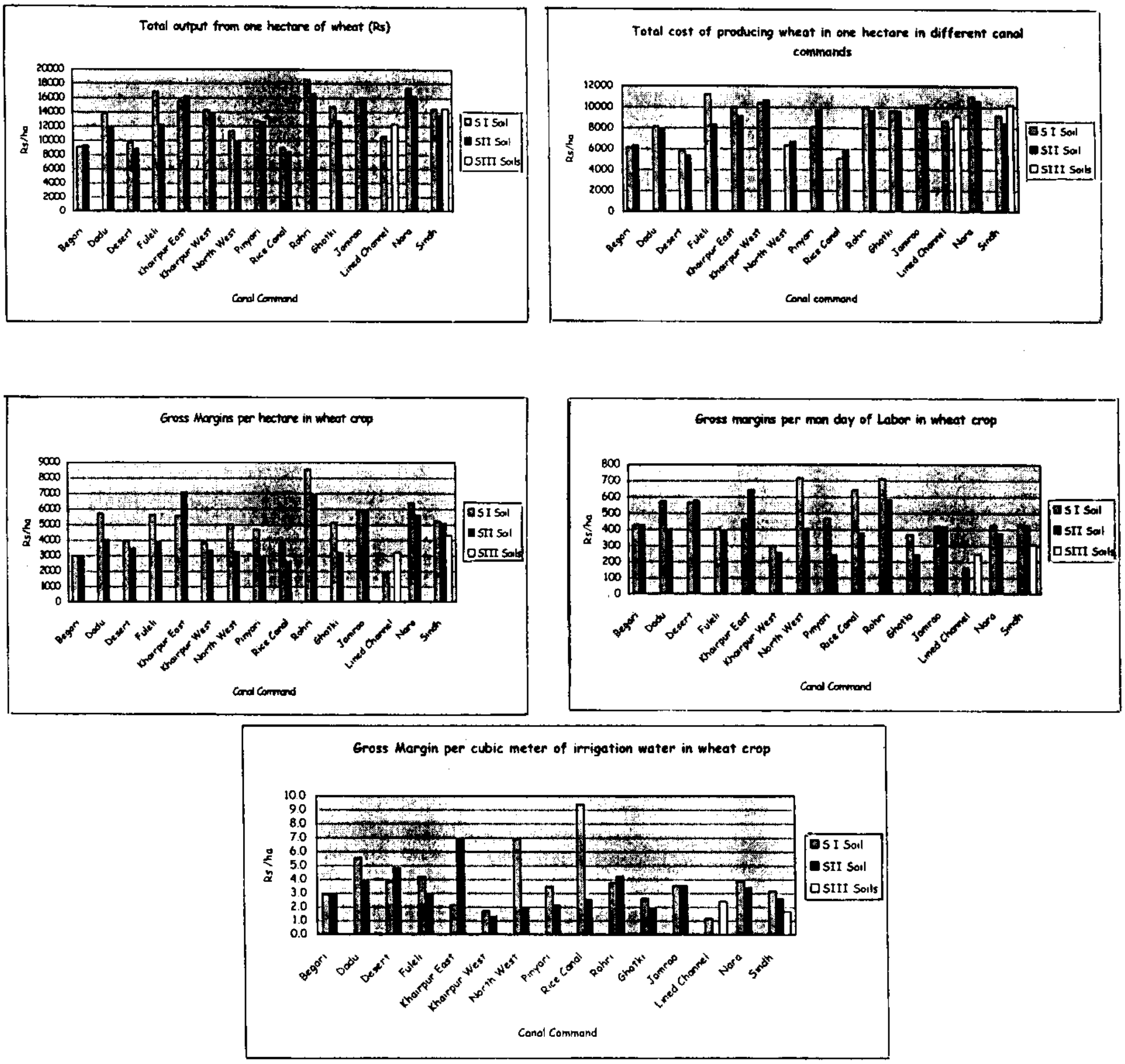


Table 61. Net Returns and Costs of Producing Wheat on different Soils in the Sindh Province (1997-98).

Wheat	Total Output	Total Output	Total Output	Total Cost	Total Cost	Total Cost	Gross Margin Per Hectare			Gross Margin/M^3 of Water			Gross Margin/Man Day of Labor		
	S I Soil	SII Soil	SIII Soils	S I Soil	SII Soil	SIII Soil	S I Soil	SII Soil	SIII Soil	S I Soil	SII Soil	SIII Soil	S I Soil	SII Soil	SIII Soil
Begari	9112	9311		6111	6306		3001	3004		2.9	2.9		429	429	
Dadu	13829	11892		8095	7850		5734	4042		5.6	3.9		573	404	
Desert	9740	8835		5784	5366		3956	3469		3.8	4.8		565	578	
Fuleli	16821	12220		11191	8336		5630	3884		4.2	2.9		402	388	
Khairpur East	15590	16224		10029	9123		5560	7102		2.2	6.9		463	646	
Khairpur West	14260	13967		10385	10643		3875	3324		1.7	1.3		298	256	
North West	11345	9975		6329	6720		5016	3255		7.0	2.0		717	407	
Pinyari	12801	12591		8105	9682		4696	2909		4	2		470	242	
Rice	8959	8470		5093	5843		3865	2627		9	3		644	375	
Rohri	18560	16650		10016	9677		8544	6973		4	4		712	581	
Ghotki	14787	12772		9642	9605		5145	3167		3	2		368	244	
Jamrao	15974	16051		10105	10204		5869	5848		4	4		419	418	
Lined Channel	10581		12310	8655		9098	1926		3212	1		2	160		247
Nara	17354	16211		10977	10603		6377	5608		4	3		425	374	
Sindh	14407	13565	14469	9193	8462	10166	5214	5103	4304	3	3	2	435	425	307

In the case of the Khairpur East Canal command, the data showed that the total income from wheat is comparatively less on the farms having SI soils when compared to the farms of SII soils. The reason for this low yield may be attributed to the fact that in Khairpur East Canal command, 15.36 % of the cultivated area (having SI soils) on sample farms is under date-palm orchards and the sample farms have about 8.55 percent of the cultivated area under SII soils. The low yield of the wheat crop reported by the farmers is due to the practice of inter-cropping of wheat in the date-palm orchards. the majority of the farmers reported that they focused their attention mostly on the date-palm orchards (as it is the most profitable enterprise). The overall income from these plots of land was reported higher, but since the wheat is sown as an inter-crop, its yield is low. The other reasons for the comparatively lower yield (on the farms having the S-I soil in the sample farms located on the Jamrao and the Khairpur East Canal command areas) was reported to be the scarcity of irrigation water. About 30 percent of the sample farms in these areas reported the scarcity of water as a major reason for low wheat yield on their farms. There may be another reason that SI soils are medium-textured soils with good permeability, whereas SII soils are medium-textured with a high watertable having somewhat more water-holding capacity. So, in the case of water shortages, crops in S-I lands were affected more when compared to class S II lands. Similarly, in the Jamrao Canal command area, above 40 percent of the sample farmers in classes S-I and S II soils perceived scarcity of water to be responsible for low yields. It is clear from Table 61 that the cost of production for a hectare of wheat in areas irrigated by the Begari, Desert and Rice Canals is less when compared to other areas. It may be due to the fact that in these areas, the farmers just broadcast the wheat seed in wet paddy soils, normally, with zero tillage. Another reason for the low cost for raising the wheat crop in these areas may be that the farmers could provide only one irrigation to the wheat crop, which lowers the level of fertilizer and inputs.

B. Cost of Production and Returns from the Cotton Crop

Table 62 provides the cumulative figures on the cost of production, gross revenue, gross margin, net returns/ha, Gross margin / M3 of water and gross margin/man-day of labor employed in the cotton production on the sample farms in the S-I and S-II soil categories (the detailed calculations are given in Appendices C1-C8) from a hectare of cotton crop. Returns from cotton range from Rs. 21,126 in the Khairpur East Canal command to Rs. 46,100 in the Nara Canal command. The highest returns come from the Nara Canal command area, which is a wheat-cotton area. The Nara Canal is not only on the top due to its high output but also to its gross margins. The gross margin is quite low in the Khairpur West Canal command, as is output. As far as the gross margin per cubic meter of irrigation water is concerned, returns are the highest (Rs. 9.3) in the Fuleli Canal. The reason for this may be that in the Fuleli Canal command the watertable fluctuates more and crops need less water. In the table it can be seen that returns are going to decrease as we shift from class SI soils to the following class. In the Fuleli and Khairpur West Canal commands there are some deflections from the standard described above. Returns are more from SI soils when compared with SII soils. It may be because the Fuleli Canal command watertable continues to fluctuate. So due to the fluctuation in watertable, classes of soils may not at all prevail, but may change with variation in the watertable depth. Thus, the contrast in returns is possible due to the disagreement in the time of the interview and survey undertaken by the soil survey team. Gross margins per man-day of labor range from 208 in the Khairpur West Canal command for cotton to 792 in the Rohri Canal command. In the Khairpur West Canal command, the output is very low, although laborers have to work the same hours as in other canal commands. Therefore, gross margins in those farms located in the Khairpur West Canal command are very low for the labor input.

Figure 7. Total Output, Total Cost and Gross Margins from the Cotton Crop (Rs./ha).

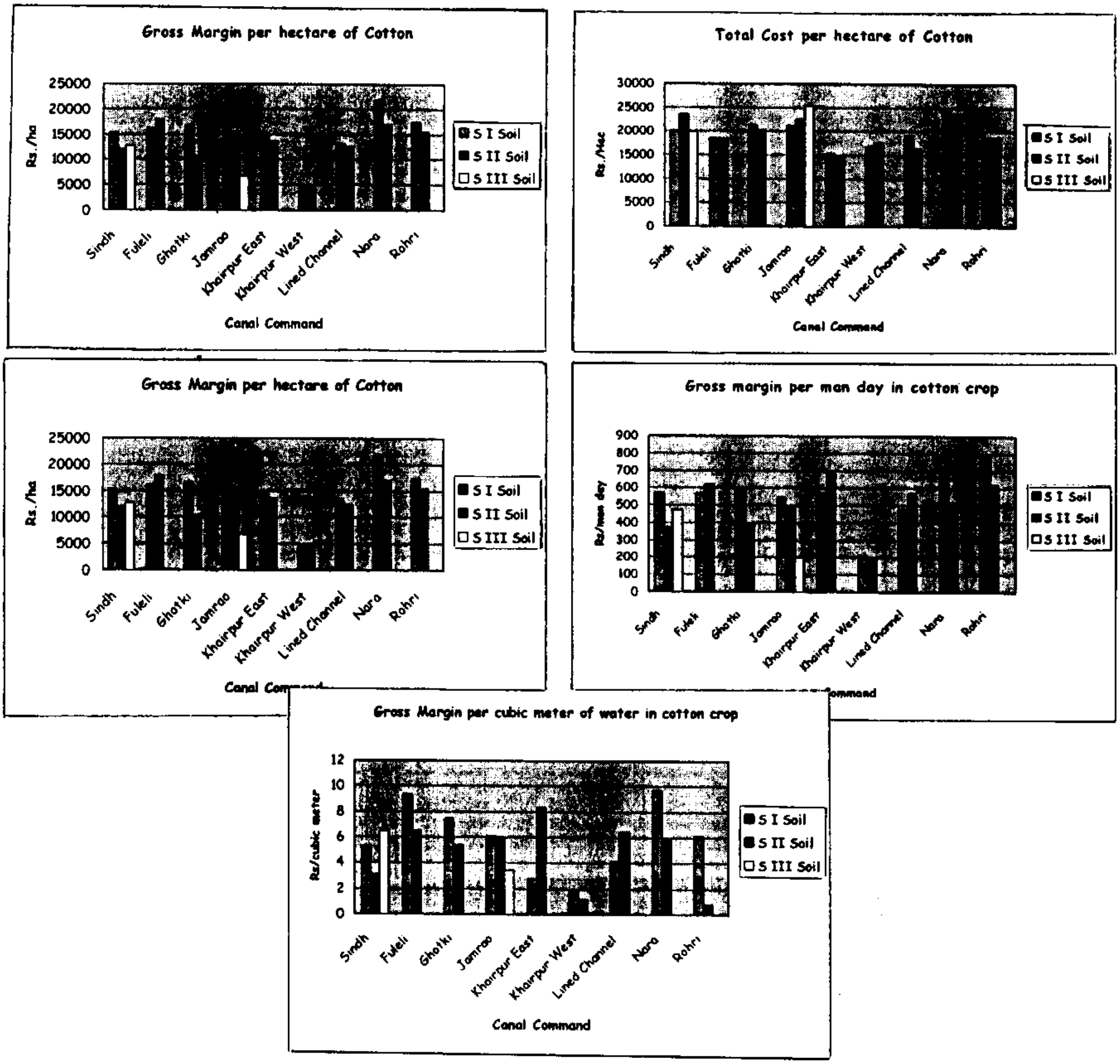


Table 62. Returns/ Costs of the Cotton Crop in different Soil Classes in the Sindh Province (1997-98).

Cotton	Total Output			Total Cost			Gross Margin per hectare			Gross Margin /M^3 of water			Gross Margin /man day of labor		
	S I Soil	S II Soil	S III Soil	S I Soil	S II Soil	S III Soil	S I Soil	S II Soil	S III Soil	S I Soil	S II Soil	S III Soil	S I Soil	S II Soil	S III Soil
Sindh	35385	35420	32547	20017	23488	19768	15367	11931	12779	5.3	3.1	6.5	569	373	473
Fuleli	34587	36290		18529	18356		16058	17934		9.3	6.5		567	618	
Ghotki	37840	30723		21198	20243		16642	10480		7.4	5.4		594	388	
Jamrao	36880	38000	32004	21172	22601	25337	15708	15398	6667	6.1	6	3.4	542	497	196
Khairpur East	30114	28203		15147	14598		14967	13605		2.8	8.3		570	680	
Khairpur West	21126	22040		16561	17505		4565	4535		1.8	1.2		208	197	
Lined Channel	32120	28785		19148	16276		12972	12509		4.1	6.4		480	569	
Nara	46100	40640		24258	23635		21842	17005		9.7	5.9		683	515	
Rohri	35994	34272		18559	18763		17434	15508		6.1	0.8		792	620	

Table 63. Returns/ Costs of the Sugarcane Crop in different Soil Classes in the Sindh Province (1997-98).

Sugarcane	Total Output			Total Cost			Gross Margin per hectare			Gross Margin/M3 of Water			Gross Margin/man day of labor		
	S I Soil	S II Soil	S III Soil	S I Soil	S II Soil	S III Soil	S I Soil	S II Soil	S III Soil	S I Soil	S II Soil	S III Soil	S I Soil	S II Soil	S III Soil
Sindh	64420	69935	60718	28030	36158	28904	36390	33777	31814	5.5	3.3	6.0	933	689	795
Dadu	58107		53905	27068		26530	31039		27375	5.8		5.1	817		740
Fuleli	64467		58966	34057		28590	30410		30375	5.7		5.4	661		759
Ghotki	69801		35568	26528		22334	43273		13234	8.4		4.6	1202		441
Jamrao	71531		61004	32178		28905	39353		32100	6.6		17.3	875		783
Khairpur East	57186		44790	23737		23628	33449		21162	8.1		8.2	1014		683
Khairpur West	46546		43472	23171		20640	23374		22832	7.3		5.2	1113		787
Lined Channel	69837		59935	31735		29575	38102		30360	6.7		4.6	866		723
Nara	71926		70871	32072		31681	39855		39190	6.4		7.8	813		911
North West			48214			25312			22903			7.2			694
Pinyari	48906		65464	29816		28850	19090		36614	2.8		6.1	444		893
Rohri	64853		64190	26819		28624	38034		35567	8.6		7.1	1028		889

Table 62 shows the total income is comparatively more in areas irrigated by the Nara and Jamrao Canals when compared to other canal commands. In most of these canals the cropping pattern is cotton after cotton. Farmers continue picking cotton for nine months, and the cotton crop remains standing in the field up to February. So, the yield of cotton may be more in that type of cropping pattern.

C. Cost of Production and Returns from the Sugarcane Crop

Table 63 presents the statistics for the total income and net returns, gross margin, return per cubic meter of irrigation water and returns for per man-day of labor gained by farmers in the survey, from sugarcane crop production. The principle is the same as described for wheat earlier, i.e. the trend in returns is downward from class SI to the next soil class (the detailed cost of production for sugarcane production across different canal commands is annexed in Tables D1-D10). It the total output ranges from Rs.4,654 per hectare to Rs.71,926 in the Nara Canal command area. Usually, the total returns from sugarcane is more in SI soils than in SII soils, but a deviation may be seen in the case of the Pinyari Canal command. In the Pinyari Canal command the returns are more in soil class SIII (Rs.65,464) when compared to soil SI (Rs. 48,906). The reason is because the area surveyed in the Pinyari Canal command comes under District Badin, which is the tail of the Pinyari Canal. So, in those areas the water is generally scarce. Sugarcane is a high delta crop. Soil class SIII falls under fine-textured waterlogged soil, which becomes useful for the crop in severe water dearth. That is why the majority of the farmers (80%) in that area prefers to grow sugarcane in SIII soil class to derive the ease of subsoil-irrigation. Another reason for high returns in SIII is that the farmers intensify more on land preparation and the application of pesticides when compared with the SI class. There is another case of deviation present in the Nara Canal command; the total income in SI soil class (this is more than SIII class, but its net returns, because of a higher cost of production) has gone down. This means that an increased application of inputs than required is going to decrease the net returns instead of increasing the output.

Table 63 indicates that the Ghotki Canal command has the highest net returns (Rs.43,273) from sugarcane in SI soils, and the lowest in SIII soils when compared to other canal commands in the survey. This means that a high watertable in the Ghotki Canal command adversely affects the sugarcane yield. This is because of SCARP tubewell operations in some areas in the Ghotki Canal command. Access to irrigation water is not a big problem, so most of the farmers prefer to grow sugarcane in class SI soils instead of SIII soils.

The sugarcane crop yields the highest returns in the areas irrigated by canals on the Left Bank of the river Indus. This is due to the fact that sugarcane is an annual crop, and demands irrigation water around the year. The basis is that on the right side of the River Indus the sugarcane crop is not supplied with the required irrigation water, particularly in the Rabi season. That is why the yield, area cropped and returns from sugarcane are comparatively less on the Right Bank than on the Left Bank.

Table 63 indicates that the cost of production in the Dadu and North West Canal irrigated areas is comparatively less than in other canal commands in the survey. The total cost for a hectare of sugarcane in the SI class ranges from the lowest figure of Rs.23,171 in the Khairpur West to the highest figure of Rs.34,057 in the Fuleli Canal. Whereas, for SIII this varies from Rs.20,640 in the Khairpur West to Rs.31,681 in the Nara Canal. This is showing that farmers in the Fuleli and Nara Canals tend to spend the maximum money on a hectare of sugarcane, and the least in the Khairpur West Canal command irrespective of soil classes.

In the Nara and Jamrao Canals output is the highest, but gross returns are the highest is in the Ghotki Canal command area. As they invest less than for the Nara Canal and their total is not so high, therefore, gross margins are higher in the Ghotki when compared to the Nara and Jamrao Canal command areas.

As far as the gross margins per cubic meter is concerned, the highest returns came from the Rohri Canal command area. Trends in gross margins per cubic meter are different in soil types. The highest in the Jamrao Canal command area, while the lowest is in the Pinyari Canal command area. Gross margins per man-day vary in different canal command, and soil types. The highest is in the Ghotki Canal command area, which is Rs.1,202 and the lowest in the Nara Canal in SI, which is Rs.813. In SIII soils, this range varies from Rs.441 to Rs.911.

D. Cost of Production and Returns from the Rice Crop

Table 64 presents the results about costs, output, gross margins and returns for each cubic meter of water and each man-day of labor. In the case of the total output, rice has quite a contrary response to high watertable when compared to wheat, cotton, and sugarcane. Normally, most field crops are avoided under undue exposure to the waterlogged soil conditions because of its adverse effects. But, rice, due to its unique physiological characteristics, is, otherwise provided, artificially created under waterlogged soil conditions, which proliferates growth and subsequently, high yield through frequent watering and excess flooding. In complete negation of the trend in net returns observed in the other crops, returns from rice are relatively higher in SIII soils when compared to the SI soil class. SIII soils are heavy-textured with good water-holding capacity, which supports the rice growth. That is why more than 65 percent of the rice growers prefer SIII soils for the rice crop (Table 64).

Gross margins per cubic meter of irrigation water is the least for the rice crop, because the rice crop is a high delta crop requiring more water than other crops within a short duration (the detailed cost of production for rice production across different canal commands is annexed in Tables E1-E14). Abiana for rice crops is almost the same as that for wheat, and gross margins are not so high, therefore, gross margin per cubic meter of water is the lowest for rice, which ranges from Rs.1 to Rs.2 per cubic meter of water. The gross margin per man-day is the highest for the Rice Canal (Rs.905) and the least for the Pinyari (Rs.146) Canal command area. A gross margin per man-day of labor is usually more in SIII soils when compared to SI soils. The reason is that SIII soils are somewhat waterlogged soils, which supports rice growth and gives good returns. Similarly, gross margins per man-day are more in canal commands where the output is very high, and low in low productive areas.

Figure 8. Total Cost, Total Output and Gross Margin From Sugarcane Crop (Rs./ha).

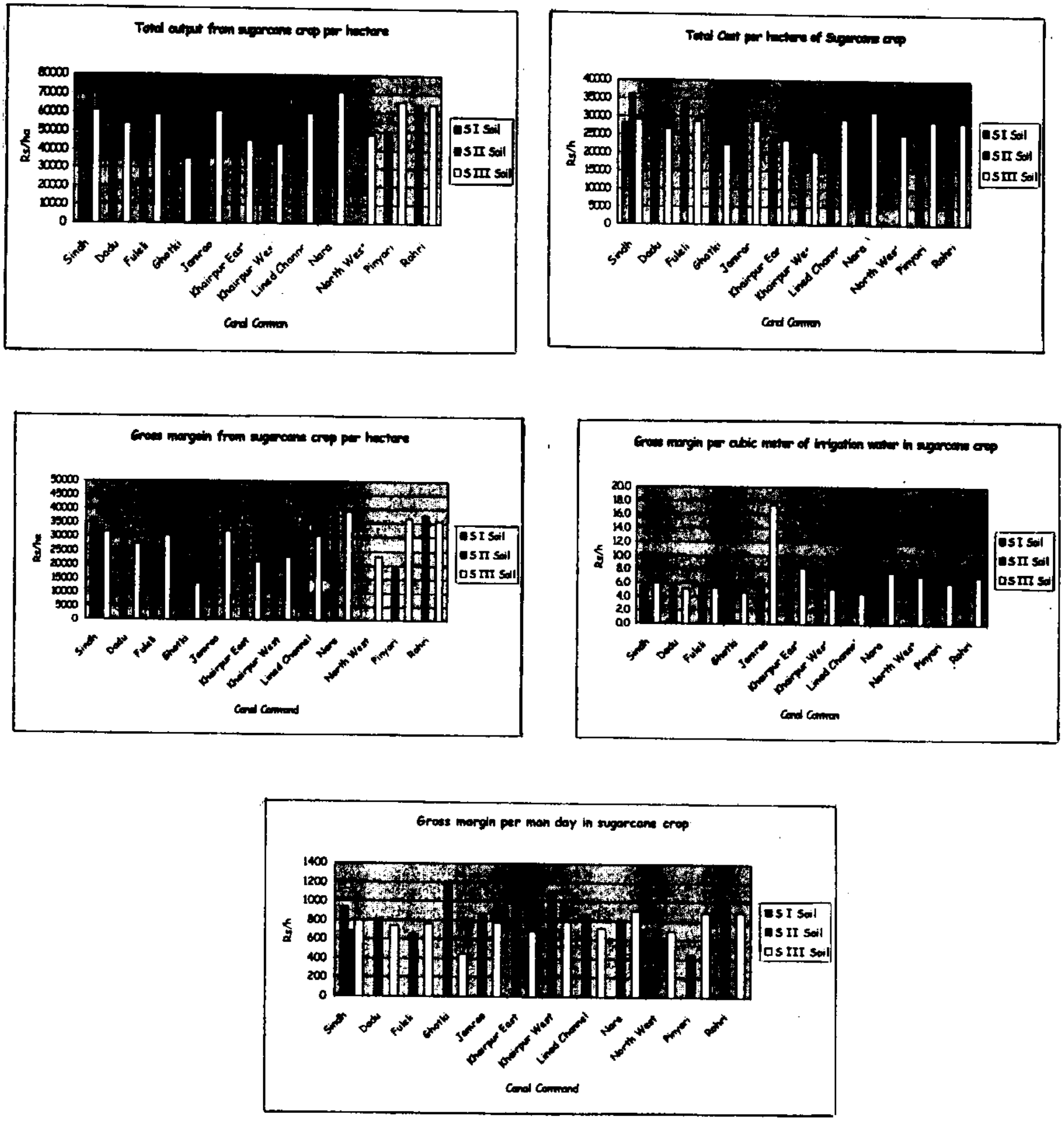
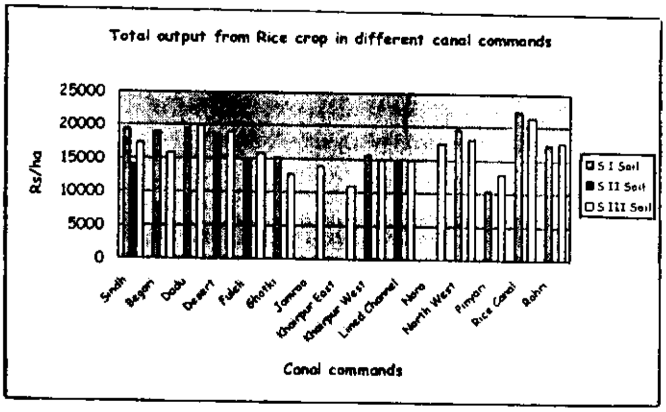
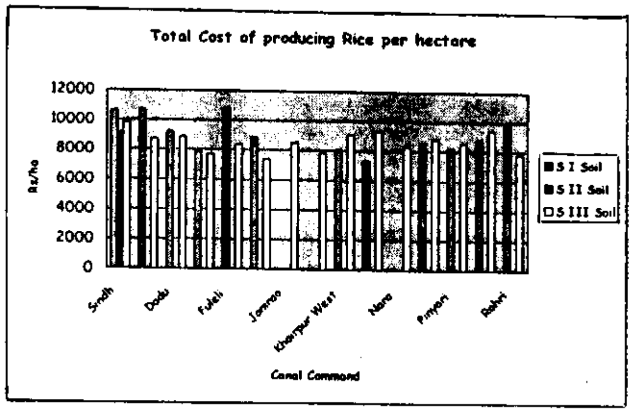


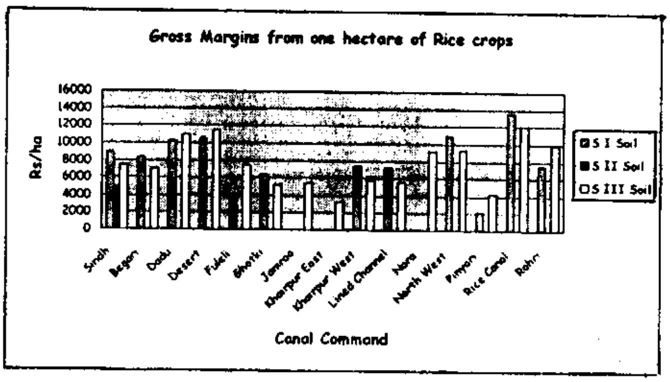
Table 64. Returns/ Costs of the Rice Crop in different Soil Classes in the Sindh Province (1997-98).

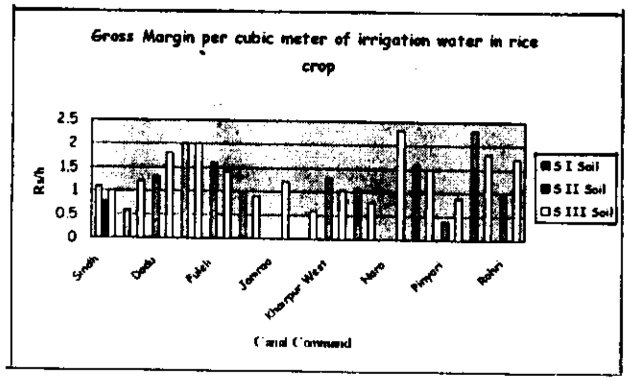
Rice	Total Output			Total Cost			Gross Margin Per hectare			Gross Margin $/M^3$ of water			Gross Margin /man day of labor		
	S I Soil	S II Soil	S III Soil	S I Soil	S II Soil	S III Soil	S I Soil	S II Soil	S III Soil	S I Soil	S II Soil	S III Soil	S I Soil	S II Soil	S III Soil
Sindh	19485	14069	17290	10629	9090	9781	8856	4978	7509	1.1	0.8	1	403	293	417
Begari	18965		15715	10666		8700	8299		7015	1		1	437		438
Dadu	19405		19835	9143		8832	10262		11003	1		2	570		688
Desert	18470		19030	7923		7636	10547		11394	2		2	703		814
Fuleli	14820		15811	10825		8343	3996		7468	2		1	250		498
Ghotki	15175		12595	8803		7388	6372		5207	1		1	374		347
Jamrao			13931			8502			5429			1			362
Khairpur East			11010			7801			3209			1			214
Khairpur West	15561		14820	8101		9055	7460		5765	1		1	466		339
Lined Channel	14602		14796	7326		9307	7276		5489	1		1	428		305
Nara			17424			8272			9152			2			654
North West	19560		18005	8583		8752	10977		9253	2		2	610		544
Pinyari	10375		12790	8180		8539	2196		4251	0		1	146		283
Rice Canal	22300		21455	8726		9389	13574		12066	2		2	905		670
Rohri	17315		17640	9892		7811	7423		9829	1		2	464		756

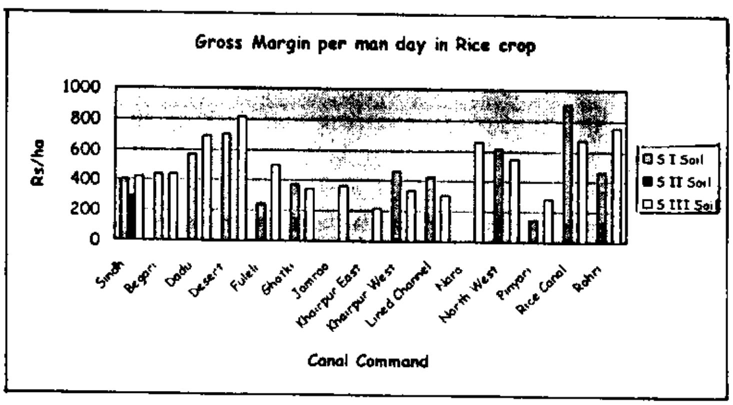
Figure 9.Total Output, Total Cost and Gross Margin from the Rice Crop (Rs/Ha).











IX Conclusions

The conclusions emerging from the study are summarized below.

- The study reveals that the total cultivated area in 13 districts amounted to 2.85 Mha out of 3.46 Mha of the farm area. There exists 0.566 Mha of land on agricultural farms that could be cultivated, but is classified as culturable waste.

- The main source of irrigation for agriculture is canal water. Out of the total of 3.18 Mha of irrigated agricultural land, 2.66 Mha are irrigated with canal water.

- In the study area, about 87 percent of the farms prefer to use canal water as a source of irrigation. Only 1 percent of farms depends upon tubewell water and about 12 percent of farms supplement canal water supply along with tubewell water.

- This conjunctive use of water is due to canal commands having some areas of groundwater, which are less saline. According to WAPDA, the culturable command areas of the Nara, Lined Channel, Fuleli and Pinyari Canals are having totally saline groundwater. Therefore, none of the respondents in these canal commands irrigate their fields with tubewell water, except the Khairpur East Canal command where only three farmers were found irrigating with tubewell water by mixing it with canal water.

- The study shows that 39 percent of farmers are satisfied with the current water supply. Also, about 61 percent of sample farmers reported the shortage of irrigation supplies on their farms in view of the current water supply.

- Among other reasons for the shortage of irrigation water, the most common reason was that they receive less water than allocated. The time allocated per unit of area is less than the time required for filling it.

- The survey results revealed that almost 58 percent of the farmers do not know the time exact allocated for irrigation. They irrigate their fields whenever they need to. They do not apply the warabandi system as followed in the Punjab Province. All of the farmers open their nakkas simultaneously to irrigate their fields. Most of the time tail-enders are the main sufferers.

- The second reason for the lack of knowledge about the time allocated is that some large farmers have their own watercourses to irrigate their fields. That watercourse is allocated to one farm continuously. The tenants of the same landlord get water from the same watercourse without any proportion and time, and they were unable to give any estimates about the time allocation for their turn of water.

- This practice is more common on the Right Bank of the Indus River, especially in the Begari, Dadu and Rice Canal areas. Farmers reported having enough water in the Kharif and Rabi seasons and they use the same moisture for wheat and sarsoon because soils in these regions are fine-textured and can retain moisture for comparatively longer periods. The excess soil moisture (at the harvest of the rice crop) is also reported to be a problem for wheat sowing, as soils do not come to the field capacity level for wheat sowing, and usually delays the wheat sowing on the Right Bank of the Indus River.

- As far as the time required to fill one hectare is concerned, about 64 percent of the farmers mentioned this time to be less than two-and-a-half hours.

- The survey results show that out of the total sample farms, about 8 percent of farms reported using lift pumps to irrigate their fields, of which 16 farms are located on the Right Bank of the Indus River, and about 117 farms on the Left Bank. Lifting irrigation water increases the cost of irrigation and reduces the profitability of crops. The farmers in those regions where water is lifted reported that they avoid planting high delta crops.

- About 37 percent of farmers stated that the problem of water shortage is due to a lower discharge in the distributary. The major reason for not using groundwater is its bad quality.

- In Sindh about 65 percent of the sample farmers were of the view that the watertable has increased, which has worsened the problem of drainage on their farms.

- The survey results revealed that 11 percent of the farms adopt certain measures, but lack resources or cooperation from other farmers to solve the drainage problem.

- The study shows that about 6 percent of the farms tried to construct private drains, but the neighboring farms were uncooperative. They were not even willing to allow these farms to expel drainage water into the drainage system.

- The results show that the cropping intensity in Sindh varies from 105 percent in the Nara to 192 percent in the Rice Canal.

A) Mechanization

- About 100 percent of wheat threshing are reported to be done with the wheat thresher. The Gobal is reported to be the main implement, used by 46 percent of farmers for land preparation in the canal commands of the Left Bank of the Indus River. Of these users, 78 percent hired the Gobal, and only 22 percent used their own.

- Farmers reported the use of the cultivator (Eleven-tined) on both sides of the Indus River in the Sindh Province. About 81 percent of the sample farmers reported the use of the cultivator to cultivate their fields.

- The Punj Phara is also used on the Right Bank of the Indus River (in the rice-wheat cropping zone). Almost 67 percent of the sample farmers in the Sindh Province reported the use of the Punj Phara for land preparation. The concept of using the Punj Phara is somewhat different on both sides of the river Indus. On the Left Bank this implement is large in size and is used for deep tillage, while on the Right Bank it is used as a cultivator.

- The average wheat yield during 1995-96 on farmers' fields in the Sindh Province was recorded as 2.11 tons/ha, when compared to 5.02 tons/ha at the experimental stations.

- During the survey, 44 percent of the farmers (mostly located in the canal command areas of the Begari, Desert, Fuleli, Ghotki, Khairpur East, Khairpur West, Pinyari and Rice Canals) regarded the high watertable to be the contributor towards the lower yields of wheat. About 23 percent of the farms regarded the scarcity of irrigation water to be the reason for the low production of wheat on their farms.

- The regression results show that in Hyderabad, Jaccobabad, Shikarpur, Larkana and Thatta Districts, the increase in the **wheat area** is not accompanied by a consistent increase in productivity that initially increased during 1970, and thereafter, decreased between 1980 and 1990. In the case of the Badin, Sanghar and the Sukkur Districts, the trend in the area under wheat shows a decline during the period of 1980-90, and afterwards, the coefficient for the area under wheat area increases. For the Larkana, Mirpurkhas, Nawabshah, Shikarpur and Thatta Districts, the coefficients for the area under wheat consistently shows an increasing trend during the 1990s.

- The regression coefficients for the overall trend in the **wheat yield** showed an increase during the 1980s in all of the districts, except Hyderabad, Jaccobabad, Shikarpur and Thatta. For the Badin District, the coefficients for the wheat yields also depict a decline in productivity during the 1990s due to the drainage problem, high watertable and the scarcity of irrigation water at the tail end.

- Regarding the cotton crop production, the results show that a stagnant production trend until 1991-92, replaced by an increasing trend afterwards, contributed in part by the variety of improvements and more resolute pest scouting. The record level of production (1.86 million bales) in the Sindh Province was attained during 1995-96, after about six years of the virus attack.

- The temporal comparison of the cotton yield across districts in Sindh shows an increasing trend in cotton productivity over time during 1947-48 to 1994-95.in the districts of Khairpur, Sukkur and Nawabshah.

- The results show that the regression coefficient for the yield during the 1970s in the districts of Badin, Hyderabad, Jaccobabad, Khairpur, Larkana, Nawabshah, Sanghar, Sukkur, Tharparkar and Thatta are positive; however, it becomes negative in the districts of Badin, Jaccobabad and Nawabshah during the 1980s. This rate of decrease further intensified in the Districts of Badin, Hyderabad, Shikarpur and Tharparkar during the 1990s.

- The regression coefficients for the area under the cotton crop among all of the 13 districts of Sindh showed an increasing trend during the 1970s, which was significant at the 99 percent level of confidence. A declining trend in the cotton crop was observed for the Districts of Dadu, Khairpur, Sanghar and Sukkur. For the Districts of Dadu and Sukkur, the coefficient for the area was significant during the 1980s and showed a further declining trend during the 1990s with respect to area under cotton crop in the Districts of Dadu and Shikarpur.

- The total area under paddy in the Sindh Province was about 0.642 Mha, which was about 29.71 percent of the paddy area in Pakistan (2.161 Mha). About 1.697 MT of rice has been produced from the Sindh area during 1995-96. The average yield was about 2.64 tons/ha.

- The examination of estimated regression coefficients for the paddy yield in the equation for the districts in Sindh showed that the per-unit paddy yield depicted an increasing trend from the 1970s to 1990s, except for the Districts of Badin, Dadu, Jaccobabad and Tharparkar. The regression coefficients for the yield during the 1980s and 1990s for the remaining districts are statistically significant and had the positive sign.

- The estimated regression coefficients for the paddy area in all the 13 districts have positive coefficients that are statistically significant at the 99 percent level of confidence, showing that during the 1970s the area had a positive relationship with the production of rice in the Sindh Province. During the 1980s the regression coefficients for area in the Districts of Badin, Nawabshah and Shikarpur showed a declining trend in the area under the cultivation of rice. The Districts of Badin, Larkana, Nawabshah, Sanghar and Shikarpur showed a negative trend during the 1990s.

- The study shows that the acreage under the sugarcane crop in the Sindh Province has expanded from 0.007 Mha during 1947-48 to about 0.254 Mha during 1995-96. The yield of sugarcane has increased more profoundly than any other crops in Sindh. Its yield was 34 tons in 1974-75. The average yield in 1994-95 was 57.3 tons per ha. This increase in yield could be due to good climatic conditions, better management, high-yielding varieties and more input.

- The regression results for all the districts of Sindh where grow sugarcane is grown, show an increasing trend in the sugarcane area that is offset by a declining trend in the area during the 1990s in the District of Khairpur.

- Regarding the productivity of sugarcane, except for the Districts of Hyderabad, Jaccobabad, Shikarpur and Sukkur, all the regression coefficients for the yield during the 1980s are positive and statistically significant at the 99 percent level of confidence. The regression coefficients show that the sugarcane yield declined during the 1990s in the Districts of Jaccobabad and Shikarpur.

- At the Left and Right Bank area levels, as well as at the overall Sindh level, the postulated direct relationship between farm size and culturable wastelands is empirically valid during the time periods for the 1960s, 1970s, 1980s and 1990s (before, during and after the Green Revolution/SCARP/drainage projects). The elasticity coefficients for the farm sizes in the 1960s are statistically significant in all of the 12 districts at the 99 percent level of confidence, and have the positive signs. The magnitude of the coefficient for the farm area being greater than 1 for all the districts show that a one percent increase in the farm size in these districts led to more than a 1 percent increase in the CWA in the Sindh Province.

- The results show that for all the districts except Larkana and Shikarpur, the technology did play a role until the 1980s in reducing the CWA. Afterwards, this role was non-significant in reducing the CWA, as the 1990 intercept dummies were non-negative and significant at the 99 percent level of confidence for these districts.

- The elasticity coefficients for the farm sizes showed a positive relationship between farm size and the CWA in all of the districts. The results show that there was no significant change in the relationship between the farm size and CWA in the districts of Badin, Dadu, Hyderabad, Sanghar and Thatta when compared to elasticity coefficients for the farm sizes in the 1960s.

- For the Jaccobabad and Sukkur Districts, the elasticity coefficients for the farm sizes during the 1970s and 1980s showed an increasing trend in the CWA, with an increasing farm size that further increased thereafter. In the case of the Nawabshah District, the coefficient shows an increasing trend of culturable waste area until the 1980s, and afterwards, declines during the 1990s. In the case of Districts Khairpur, Larkana, Shikarpur and Tharparkar, the study shows a similar trend of CWA with respect to FAT during the 1960s, but this trend decreases during the 1980s in the case of Khairpur and Shikarpur and further declines in the Districts of Khairpur, Larkana, Shikarpur and Tharparkar.

- The regression results show that the proportion of area under irrigation has a negative and statistically significant (at the 99 percent level of confidence) relationship with CWA during the 1960s in the Districts of Dadu, Khairpur, Larkana, and Sukkur and this relationship becomes more negative afterwards during the 1980s and 1990s. In all of the other districts, the elasticity coefficients for the proportion of irrigated areas on the farms were not significant.

- The irrigation coefficient showed a positive relationship with the cropping intensity (CI), for all the districts in all of the Sindh Province. During 1960 the irrigation regression coefficient was positive and significant at the 99 percent level of confidence in the Districts of Badin, Dadu, Jaccobabad, Hyderabad, Khairpur, Nawabshah, and Shikarpur. This relationship continued in the Districts of Hyderabad, Jaccobabad, and Shikarpur during the 1990s. This means that if irrigation supplies were increased, a tendency to bring more area under cultivation exists, and thereby, reduces the culturable waste areas in these districts, except in the Districts of Dadu, Khairpur and Tharparkar, where this relationship was further augmented during the 1990s.

- The results show that, at the Sindh level, the measure of inefficiency across farm categories during 1998 was higher on the larger farms at the canal command level; the large and medium farms of the Jamrao, Nara, Khairpur East, Khairpur West, Lined Channel, Rice, Fuleli and Pinyari Canals. These results, when viewed in the context of the estimates of the inefficiency indices calculated from the 1997-98 Sindh survey data, confirm that the small farmers are the most efficient in the potential utilization of the farmlands.

- The inefficiencies of the medium and large farmers in the canal commands of Khairpur East, Khairpur West, Lined Channel, Rice, Fuleli and Pinyari Canals are much higher than the small farms in these canal commands. The results also show that the medium and large farms in the canal commands of the Rice, Desert, North West and Dadu Canals are comparatively more efficient. This shows that much scope exists to improve the efficiency of medium and large farms in the commands of the Khairpur East, Khairpur West, Lined Channel, Rice, Fuleli and Pinyari Canals.

- The additional area, which may be cropped through the improvement in cropping intensity, was determined to be about 1.42 Mha; the major contribution being from the medium and large farm holdings.

- The total increase in cropped area at the Sindh level, by making improvements in the cropping intensity and by bringing in the additional area from culturable waste lands, amounts to 1.94 Mha, which is about 56 percent of the total croppable area. Of this potential recovery, 28 percent is from the improvement in cropping intensity and the remaining area comes from the culturable wastes.

- This study shows that, on average, about 29, 24, 18 and 8 percent of the GCA, respectively, fall under the wheat, rice, cotton and sugarcane crops in the Sindh Province. If this proportion of distribution is maintained, then about 0.55 Mha will be cultivated under the wheat crop, 0.463 Mha will be cultivated under the rice crop and the average area under the cotton and the sugarcane crops will be 0.336 and 0.155 Mha, respectively. The major contribution is coming from the canal commands of the Rohri, Nara, and Ghotki Canals and Lined Channel, which are the major contributors in the area for the wheat crop.

- The estimates of the potential productivity of the four major crops in the Sindh Province shows that the canal command areas of Sindh have the additional potential to produce 1.11 million tons (MT) of wheat, 1.66 MT of rice, 0.579 MT of cotton and 10.34 MT of sugarcane.

B) Wheat

- The estimates of regression coefficients show that the maximum response from the LNCOFERT coefficient on the wheat productivity was seen in the farms located at the Fuleli Canal command area (0.88), when compared to LNCOFERT regression coefficients for the farms located in the command areas of the Begari (0.33), Dadu (0.42), Desert (0.45), Ghotki (0.05), Jamrao (0.22), Khairpur E. (0.16), Khairpur W. (0.39), Lined Channel (0.46), North West (0.07), Pinyari (0.61) and Rohri Canals (0.40). In the case of the LNCOLAND coefficient, the regression coefficients ranged between 0.02 in the Ghotki Canal command area to 0.91 in the Fuleli Canal command area. This shows that a unit increase in the cost of land preparation will increase the wheat productivity by 0.51, 0.14, 0.49, 0.29, 0.91, 0.49, 0.72, 0.30, 0.49, 0.84, 0.42, 0.26, 0.61 percent on the farms located in the Begari, Dadu, Desert, Fuleli, Ghotki, Jamrao, Khairpur E, Khairpur W, Lined Channel, North West, Pinyari, Rice and Rohri Canal command areas, respectively. The regression results show that the LNNOIRR coefficient is significant at the 99 percent level of confidence in the equations providing results from the Begari, Dadu, Ghotki, Jamrao, Khairpur E, Khairpur W, North West and Rice Canal command areas. These results show that a one percent increase in the LNNOIRR will increase the productivity of wheat by 0.40, 0.25, 0.13, 0.58, 0.18, 0.18, 0.13 and 0.43, respectively, on the farms located in the Begari, Dadu, Ghotki, Jamrao, Khairpur E, Khairpur W, Northwest and Rice Canal command areas. The regression results for the

LNFSIZE coefficient show that it is negative and statistically significant at the 99 percent level of confidence on the farms located in the canal command areas of the Begari, Ghotki, Jamrao, Khairpur W, Rice and Rohri Canals. The LNFSIZE coefficient shows that a one percent increase in the farm size lowers the wheat productivity by 0.96, 0.20, 0.97, 0.30, 0.02, and 0.38 percent, respectively, on the farms located in the command areas of the Begari, Ghotki, Jamrao, Khairpur W, Rice and Rohri Canals.

C) Cotton

- The farm areas reporting cotton production includes the command areas of the Fuleli, Ghotki, Jamrao, Khairpur E, Khairpur W, Lined Channel, Nara and the Rohri Canals. The Regression results for the cotton crop at these canals command areas show that the LNCOFERT, LNCOLAND, LNFSIZE and LNNOIRR came out to be statistically significant at 99 percent level of confidence.

- In the case of the regression results for the farms located in the Fuleli Canal, only the coefficient for LNCOFERT came out to be statistically significant at the 99 percent level of confidence with an explanatory power of 0.98. The LNCOFERT coefficient for the Jamrao, Khairpur W, Lined Channel, and the Rohri Canals are statistically significant at the 99 percent level of confidence and have the values 0.08, 0.76, 0.73, and 0.32, respectively.

- The coefficient for LNCOLAND came out to be significant at the 99 percent level of significance for only the farms located at the Ghotki, Jamrao, and Nara Canal command areas and have values of 0.28, 0.08 and 0.38, respectively. This shows that a one percent increase in the investment on land preparation will increase the cotton production by 0.28, 0.08 and 0.38 percent in the Ghotki, Jamrao and Nara Canal command areas, respectively.

- Contrary to the LNFSIZE coefficient in the wheat crop, the LNFSIZE in the cotton production is non-significant in the regression equations, except in the case of the Rohri Canal, where it is statistically significant at the 99 percent level of confidence and has a positive relationship with the cotton productivity. It shows that a one percent increase in the farm size on the cotton-producing farms located in the Rohri Canal area increases the cotton productivity by 0.53 percent.

- The results show that the coefficient for LNNOIRR was statistically significant at the 99 percent level of confidence in the regression equations for the Ghotki, Jamrao, Khairpur E, Nara and Rohri Canal command areas.

- It shows that a unit increase in the LNNOIRR will increase the cotton productivity by 0.11, 0.28, 0.96, 0.27 and 0.26 for the farms located at the Ghotki, Jamrao, Khairpur E, Nara and Rohri Canal command areas, respectively. The study shows that the regression coefficients were only statistically significant at the 99 percent level of confidence in the cases of the Ghotki Canal and Lined Channel, and has values of 0.09 and 0.79 for farms raising cotton.

- The variable for the cost on plant protection, LNCOPP, came out to be statistically significant in the regression equations, depicting regression results from the canal command areas of the

Ghotki, Jamrao, Lined Channel, Nara and Rohri Canal command areas. The LNCOPP coefficient shows that a one percent increase in the investment on the plant protection measures in the cotton crop increases the cotton production by 0.55, 0.63, 0.48, 0.34 and 0.29 percent on cotton-producing farms in the command areas of the Ghotki, Jamrao, Lined Channel, Nara and Rohri Canals.

D) Paddy

- The results of the Cobb-Douglas production functions for sample farms in the Begari Canal command area show that LNCOLAND had the highest value of 0.67 in comparison to LNCOFERT (0.11), LNHOEING (0.21) and LNWEDING (0.115).

- The coefficient for the farm size shows a negative relationship among farm sizes and rice production on the sample farms in the Begari Canal command area. The adjusted R2 shows that about 98 percent of the variation in the regression equation for rice production in the Begari Canal command area is explained by the independent variables included in the model.

- In the case of the regression equation for the rice farms on the Dadu Canal command area, the value of adjusted R2 is 0.84. The variables for LNCOFERT, LNCOLAND and LNWEDING coefficients came out to be statistically significant at the 99 percent level of confidence. These coefficients show that a one percent increase in the investment on LNCOFERT, LNCOLAND and LNWEDING will increase the rice production by 0.311, 0.43, 0.34 percent, respectively.

- In the case of the regression equation for the rice farms on the Desert Canal command area, the value of adjusted R2 is 0.98. The variables for LNCOFERT and LNCOLAND coefficients came out to be statistically significant at the 99 percent level of confidence. These coefficients show a one percent increase in the case of the remaining regression equation for other canal command areas. The value of adjusted R^2 is from 0.73 in the case of the Fuleli and the Rice Canals to 0.99 in the case of the regression equation for the Lined Channel command area.

- The LNCOFERT coefficient was statistically significant at the 99 percent level of confidence in the regression equations for the command areas of the Fuleli, Ghotki, Khairpur West, Lined Channel, Pinyari and Rice Canals. The LNCOFERT coefficients in these equations are 0.38, 0.38, 0.433, 0.396, 0.77, 0.19, and 0.277 for the commands of the Fuleli, Ghotki, Khairpur West, Lined Channel, Pinyari and Rice Canals, respectively.

- The LNCOLAND coefficient was statistically significant at the 99 percent level of confidence in the regression equations for the canal command areas of the Fuleli, Ghotki, Jamrao, Lined Channel, North West, Pinyari and Rohri Canals. The LNCOLAND coefficients in these equations are 0.455, 0.398, 0.897, 0.575, 0.241, 0.697 and 0.697 for the command areas of the Fuleli, Ghotki, Jamrao, Lined Channel, North West, Pinyari and Rohri Canals. For the respective farm size differentiation in canal commands, the farm size and productivity relationship was negative and statistically significant at the 99 percent level of confidence in the commands of the Begari (-0.334), and Rohri Canal (-0.595) areas.

- A positive and statistically significant (at the 99 percent level of confidence) relationship is observed in the case of the Fuleli (0.391) and Rice Canal (1.17) command areas. The coefficient for the irrigation came out to be statistically significant at the 99 percent level of confidence only in the regression equations for the command areas of the Khairpur West (0.518), Lined Channel (0.164) and Rice Canal areas (0.091).

- The regression coefficient for weeding was only significant in the command areas of the Begari, Dadu, Lined Channel, Rice and Rohri Canal areas. The estimated coefficients show that the unit increase in the expenditure on weeding increases the rice production by 0.115, 0.345, 0.171, 0.146 and 0.602 percent in the command areas of the Begari, Dadu, Lined Channel, Rice and Rohri Canal areas, respectively.

E) Sugarcane

- The regression estimates for equations from the sample farms growing sugarcane in different canal commands of the Indus River in Sindh show that overall, all the equations are statistically significant at the 99 percent level of confidence. The adjusted R2 for the regression equations are 0.99, 0.917, 0.91, 0.96, 0.80, 0.86, 0.92, 0.92, 0.83, 0.96 and 0.94 for the commands of the Dadu, Fuleli, Ghotki, Jamrao, Khairpur E, Khairpur W, Lined Channel, Nara, North West, Pinyari and Rohri Canals, respectively.

- The LNCOFERT coefficient was statistically significant at the 99 percent level of confidence in the regression equations for the canal commands of the Dadu, Fuleli, Jamrao, Khairpur E, Khairpur W, Lined Channel, Nara, North West, Pinyari and Rohri Canals. The LNCOFERT coefficient has the values of 0.95, 0.294, 0.711, 0.63, 0.59, 0.42, 0.15, 0.911, 0.523, and 0.653 for these canal commands, respectively. This means that a one percent increase in the expenditure on fertilizer increases the sugarcane production on the sample farms in the Dadu, Fuleli, Jamrao, Khairpur E, Khairpur W, Lined Channel, Nara, North West, Pinyari and Rohri Canals by 0.95, 0.294, 0.711, 0.63, 0.59, 0.42, 0.15, 0.911, 0.523, and 0.653 percent, respectively.

- The regression results show that the LNCOLAND is statistically significant in the regression equations for the command areas of the Dadu, Fuleli, Ghotki, Lined Channel, Nara and Pinyari Canal command areas. The estimated regression coefficients show that the unit increase in the cost of land preparation increases the sugarcane production by 0.06, 0.87, 0.38, 0.77 and 0.26 percent, respectively, in the command areas of the Fuleli, Ghotki, Lined Channel, Nara and Pinyari Canals. In the case of the Dadu Canal command area, the regression LNCOLAND coefficient has a negative sign (-0.58) and is statistically significant at the 99 percent level of confidence.

- The results show that the LNNOIRR coefficient is statistically significant at the 99 percent level of confidence in the regression equations for the Dadu, Fuleli, Jamrao and Rohri Canal commands. The regression coefficients have the values of 0.256, 0.491, 0.266 and 0.315 for the canal commands of the Dadu, Fuleli, Jamrao and Rohri Canals, respectively.

- The LNCOPP coefficient is statistically significant at the 95 percent level of confidence for the regression equation in the Pinyari Canal command only, and has a value of 0.08.

- The LNHOEING coefficient is significant at the 99 percent level of confidence in the command area of Khairpur East Canal and Lined Channel and have the values of 0.067 and 0.214, respectively.

- The coefficient for LNWEEDING turns out to be significant in the regression equations for the commands of the Dadu, Khairpur East and Pinyari Canals. The respective values of the regression coefficients turn out to be 0.48, -70 and 0.33 in the commands of the Dadu, Khairpur East and Pinyari Canal command areas.

F) Cost of Wheat Production and Returns

- The study estimates the cumulative variable cost of production, total income, gross margin/ha, gross margin/M3 of water, and gross margin/ man-day of labor from the production of wheat on the sample farms in Sindh. It shows that the gross returns from the wheat crop raised on the SI soils in the canal commands of the Sindh Province ranged from Rs. 8,959/ha in the Rice Canal command area to Rs 16,821/ha in the Fuleli Canal command area.

- In the case of the farm samples having the SII soil types, the gross returns range from Rs. 8,470/ha in the Rice Canal command area to Rs. 16,650 in the command areas of the Rohri Canal. The total variable cost (for providing inputs in the farms having SI soils) for raising wheat on the sample farms ranges from Rs. 5,093/ha in the Rice Canal to Rs. 11,191/ha in the Fuleli Canal command area. The net returns from the wheat crop on the sample farms in the S1 soils ranged from Rs. 1,926/ha in the Lined Channel command area to Rs. 8,544/ha in the command area of the Rohri Canal.

- The study shows that the net returns from the wheat crop production on the sample farms having the S-II soil type ranges from Rs. 2,627/ha in the Rice Canal command area to Rs. 7,102/ha in the Rohri Canal command area.

- The gross margin/M3 of water was the highest on the sample farms having the S1 soils in the Rice Canal command area. In the case of the sample farms having the soil SII the gross margin/M3 was the highest (Rs 6.91) on the farms producing wheat in the command of the Khairpur East Canal.

- The results show the gross margin per unit of labor on the sample farms having the S1 soil category ranged from Rs. 160/man-day in the canal command area of the Lined Channel to Rs. 717 in the command area of the North West Canal.

- The study also shows that the return from the wheat crop decreases as the land class is switched from SI to SII in all the canal commands of Sindh, except in the Khairpur East, Jamrao, and Lined Canal commands.

G) Cost of Cotton Production and Returns

- The study shows that the gross revenue from cotton ranges from Rs. 21,126 in the Khairpur East Canal command to Rs. 46,100 in the Nara Canal command. The highest returns come from the Nara Canal command area, which is a wheat-cotton area. The Nara Canal command area is not only on the top due to its high output, but also to its gross margins. The gross margin for cotton is quite low in the Khairpur West Canal command, as is its output.

- The estimates of gross margin per cubic meter of irrigation water shows that the returns are the highest (Rs. 9.3) in the Fuleli Canal. The reason for this may be that the Fuleli Canal command watertable fluctuates more and crops need less water. These estimates of returns show that the gross margin per unit of water declines as we shift from class SI soils to the SII and SIII classes.

H) Cost of Sugarcane Production and Returns

- In the case of the sugarcane crop, the gross revenue ranges from Rs.46,546 per hectare in the Khairpur West Canal command area to Rs.71,926 in the Nara Canal command area, while the range in the SIII class varies from Rs.43,472 per hectare to Rs.70,871 in the Nara Canal command area.

- The total returns from sugarcane is more in SI soils than in SII soils but the deviation is seen in the case of the Pinyari Canal command, where the returns are more in soil class SIII (Rs.65,464) when compared to the soil SI (Rs. 48,906). The reason is that the area surveyed in the Pinyari Canal command comes under District Badin, which is the tail of the Pinyari Canal. Thus, in those areas, water is generally scarce since sugarcane is a high delta crop. Soil class SIII falls under fine-textured waterlogged soil, which becomes useful for the crop in severe water dearth, and why the majority of the farmers (80%) in that area prefers to grow sugarcane in SIII soil class to derive the ease of subsoil-irrigation. Another reason for high returns in SIII is that the farmers intensify land preparation and the application of pesticides when compared to SI class.

- There is another case of deviation present in the Nara Canal command; the total income in the SI soil class (more than SIII class), but its net returns, because of having a higher cost of production, has gone down. This means that an increased application of inputs than required is responsible for decreasing the net returns instead of increasing the output.

- The study shows that the cost of production in the Dadu and North West Canal irrigated areas is comparatively less than in other canal commands in the survey. The total cost on a hectare of sugarcane in the SI class ranges from the lowest figure of Rs.23,171 in the Khairpur West to the highest figure of Rs.34,057 in the Fuleli Canal. Whereas, for SIII, it varies from Rs.20,640 in the Khairpur West to Rs.31,681 in the Nara Canal. This is showing that the farmers in the Fuleli and Nara Canals tend to spend the maximum money on a hectare of sugarcane and the minimum in the Khairpur West Canal command, irrespective of soil classes.

- As far as the gross margins per cubic meter is concerned, the highest returns come from the Rohri Canal command area (Rs. 8.6).

- The gross margin per man-day varies in different canal commands and soil types. The highest in the Ghotki Canal command area, is Rs.1,202 and the lowest in the Nara Canal in SI, which is Rs.813. In SIII soils, this range varies from Rs.441 to Rs.911.

I) Cost of Rice Production and Returns

- The estimates of the gross returns from the rice crop raised on the SI soils in the canal commands of the Sindh Province ranged from Rs. 10,375/ha in the the Pinyari Canal command area to Rs 22,300/ha in the Rice Canal command area.

- In the case of the farm samples having the SIII soil types, the gross returns from the rice crop ranges from Rs 11,010/ha in the Khairpur East Canal command area to Rs. 21,455 in the command areas of the Rice Canal.

- The total variable cost (for providing inputs to the farms having SI soils) for raising the rice crop on the sample farms ranges from Rs. 7,326/ha in the Lined Channel area to Rs. 10,825/ha in the Fuleli Canal command area.

- The net returns from the rice crop on the sample farms in the S1 soils ranged from Rs. 2,196/ha in the Pinyari Canal command area to Rs. 13,574/ha in the Rice Canal command area.

- The study shows that the net returns from the rice crop production on the sample farms having the S-III soil type ranges from Rs. 32,09/ha in the Khairpur East Canal command area to Rs. 12,066/ha in the Rice Canal command area.

- The study reveals that the gross margins per cubic meter of irrigation water are the least (Rs1 to Rs. 2 / M^3) for the rice crop.

- The gross margin per man-day is the most in the Rice Canal (Rs.905) and the least in the Pinyari (Rs. 146) Canal command area.

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Appendix-B1

WHEAT CROP IN BEGARI CANA (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	1327.0	6.0	7962.0
By-Product	Rs/Ha	1327.0	0.9	1194.3
Total Output	Rs/Ha			**9156.3**
Production Cost				
Seed	Kg/Ha	120.0	8.0	960.0
Fertilizer	Urea(Bags)	2.0	366.0	732.0
	DAP (Bags)	0.6	586.0	351.6
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			883.0
Family Labor	Man day*	9.0	77.0	693.0
Casual Labor (Harvesting)	Rs/Ha			954.0
Machinery Cost(Threshing)	Rs/Ha	13.3	0.5	6.6
Taxes	Rs/Ha			336.0
Irrigation	Canal(1 irrii)	411.3	0.0	0.0
	Tubewel(2irrii	205.7	2.7	548.0
Total Cost				**5464.2**
Gross Margin Per Hectare				**3692.1**
Gross Margin/M³ of Water				6.0
Gross Margin/Man Day of Labor				410.2

* Excludig Harvesting Cost

Appendix-B2

WHEAT CROP IN DADU CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	1926.0	6.0	11556.0
By-Product	Rs/Ha	1926.0	0.6	1155.6
Total Output	Rs/Ha			**12711.6**
Production Cost				
Seed	Kg/Ha	120.0	8.0	960.0
Fertilizer	Urea(Bags)	4.0	366.0	1464.0
	DAP (Bags)	1.0	586.0	586.0
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			1547.0
Family Labor	Man day*	15.0	77.0	1155.0
Casual Labor (Harvesting)	Rs/Ha			1063.0
Machinery Cost(Threshing)	Rs/Ha	1926.0	0.5	963.0
Taxes	Rs/Ha			367.0
Irrigation	Canal(3 irrii)	1028.3	0.1	112.0
Total Cost				**8217.0**
Gross Margin Per Hectare				**4494.6**
Gross Margin/M³ of Water				4.4
Gross Margin/Man Day of Labor				299.6

* Excludig Harvesting Cost

Appendix-B3

WHEAT CROP IN DESERT CANA (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	1348.0	6.0	8088.0
By-Product	Rs/Ha	1348.0	0.8	1078.4
Total Output	Rs/Ha			**9166.4**
Production Cost				
Seed	Kg/Ha	134.0	8.0	1072.0
Fertilizer	Urea(Bags)	2.0	366.0	732.0
	DAP (Bags)	0.5	586.0	293.0
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			896.0
Family Labor	Man day*	10.0	77.0	770.0
Casual Labor (Harvesting)	Rs/Ha			807.0
Machinery Cost(Threshing)	Rs/Ha	1348.0	0.5	674.0
Taxes	Rs/Ha			368.0
Irrigation	Canal(1 irrii)	411.3	0.0	0.0
	Tubewel(1irrii	308.5	0.7	201.0
Total Cost				**5813.0**
Gross Margin Per Hectare				**3353.4**
Gross Margin/M³ of Water				4.7
Gross Margin/Man Day of Labor				335.3

* Excludig Harvesting Cost

Appendix-B4

WHEAT CROP IN FULELI CANA (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	1835.0	6.0	11010.0
By-Product	Rs/Ha	1835.0	0.9	1651.5
Total Output	Rs/Ha			**12661.5**
Production Cost				
Seed	Kg/Ha	116.0	8.9	1032.4
Fertilizer	Urea(Bags)	4.0	366.0	1464.0
	DAP (Bags)	1.0	586.0	586.0
	NP (Bags)	0.2	466.0	93.2
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			2039.0
Family Labor	Man day*	16.0	77.0	1232.0
Casual Labor (Harvesting)	Rs/Ha			959.0
Machinery Cost(Threshing)	Rs/Ha	1835.0	0.5	917.5
Taxes	Rs/Ha			333.0
Irrigation	Canal(4 irrii)	1336.4	0.1	113.0
Total Cost				**8769.1**
Gross Margin Per Hectare				**3892.4**
Gross Margin/M³ of Water				2.9
Gross Margin/Man Day of Labor				243.3

* Excludig Harvesting Cost

Appendix-B5

WHEAT CROP IN GHOTKI CANAL. (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2105.0	6.0	12630.0
By-Product	Rs/Ha	2105.0	0.9	1894.5
Total Output	Rs/Ha			**14524.5**
Production Cost				
Seed	Kg/Ha	146.0	8.0	1168.0
Fertilizer	Urea(Bags)	4.0	366.0	1464.0
	DAP (Bags)	2.0	586.0	1172.0
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			1656.0
Family Labor	Man day*	21.0	77.0	1617.0
Casual Labor (Harvesting)	Rs/Ha			1210.0
Machinery Cost(Threshing)	Rs/Ha	2105.0	0.5	1052.5
Taxes	Rs/Ha			341.0
Irrigation	Canal(3 irrii)	1028.3	0.1	112.0
	Tubewel(3irrii	925.5	0.7	612.0
Total Cost				**10404.5**
Gross Margin Per Hectare				**4120.0**
Gross Margin/M³ of Water				2.1
Gross Margin/Man Day of Labor				196.2

* Excludig Harvesting Cost

Appendix-B6

WHEAT CROP IN JAMRAO CANAL.(1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2284.0	6.0	13704.0
By-Product	Rs/Ha	2284.0	1.0	2169.8
Total Output	Rs/Ha			**15873.8**
Production Cost				
Seed	Kg/Ha	135.0	8.5	1147.5
Fertilizer	Urea(Bags)	5.8	366.0	2122.8
	DAP (Bags)	1.6	586.0	937.6
	NP (Bags)	0.5	466.0	233.0
	AN (Bags)	0.2	258.0	38.7
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			2112.0
Family Labor	Man day*	21.0	77.0	1617.0
Casual Labor (Harvesting)	Rs/Ha			1118.0
Machinery Cost(Threshing)	Rs/Ha	2284.0	0.5	1142.0
Taxes	Rs/Ha			304.0
Irrigation	Canal(5 irrii)	1645.3	0.1	112.0
Total Cost				**10884.6**
Gross Margin Per Hectare				**4989.2**
Gross Margin/M³ of Water				3.0
Gross Margin/Man Day of Labor				237.6

* Excludig Harvesting Cost

Appendix-B7

WHEAT CROP IN KHAIRPUR EAST CANAL (1996-97).

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2299.0	6.0	13794.0
By-Product	Rs/Ha	2299.0	0.9	2069.1
Total Output	Rs/Ha			**15863.1**
Production Cost				
Seed	Kg/Ha	135.0	8.0	1080.0
Fertilizer	Urea(Bags)	4.5	366.0	1647.0
	DAP (Bags)	2.0	586.0	1172.0
	NP (Bags)	0.1	466.0	46.6
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			1619.0
Family Labor	Man day*	20.0	77.0	1540.0
Casual Labor (Harvesting)	Rs/Ha			1193.0
Machinery Cost(Threshing)	Rs/Ha	2299.0	0.5	1149.5
Taxes	Rs/Ha			326.0
Irrigation	Canal(3 irrii)	1028.3	0.1	111.0
	Tubewel(5irrii	1542.5	0.6	926.0
Total Cost				**10810.1**
Gross Margin Per Hectare				**5053.0**
Gross Margin/M³ of Water				2.0
Gross Margin/Man Day of Labor				252.7

* Excludig Harvesting Cost

Appendix-B8

WHEAT CROP IN KHAIRPUR WEST CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2022.0	6.0	12132.0
By-Product	Rs/Ha	2022.0	0.9	1819.8
Total Output	Rs/Ha			**13951.8**
Production Cost				
Seed	Kg/Ha	134.0	8.0	1072.0
Fertilizer	Urea(Bags)	4.0	366.0	1464.0
	DAP (Bags)	2.0	586.0	1172.0
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			1924.0
Family Labor	Man day*	18.0	77.0	1386.0
Casual Labor (Harvesting)	Rs/Ha			1193.0
		2022.0	0.4	808.8
Machinery Cost(Threshing)	Rs/Ha			
				345.0
Taxes	Rs/Ha			
Irrigation	Canal(3 irrii)	1028.3	0.1	114.0
	Tubewel(4irrii)	1234.0	0.8	988.0
Total Cost				**10466.8**
Gross Margin Per Hectare				**3485.0**
Gross Margin/M³ of Water				1.5
Gross Margin/Man Day of Labor				193.6

* Excludig Harvesting Cost Cost

Appendix-B5

WHEAT CROP IN GHOTKI CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2105.0	6.0	12630.0
By-Product	Rs/Ha	2105.0	0.9	1894.5
Total Output	Rs/Ha			**14524.5**
Production Cost				
Seed	Kg/Ha	146.0	8.0	1168.0
Fertilizer	Urea(Bags)	4.0	366.0	1464.0
	DAP (Bags)	2.0	586.0	1172.0
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			1656.0
Family Labor	Man day*	21.0	77.0	1617.0
Casual Labor (Harvesting)	Rs/Ha			1210.0
Machinery Cost(Threshing)	Rs/Ha	2105.0	0.5	1052.5
Taxes	Rs/Ha			341.0
Irrigation	Canal(3 irrii)	1028.3	0.1	112.0
	Tubewel(3irrii	925.5	0.7	612.0
Total Cost				**10404.5**
Gross Margin Per Hectare				**4120.0**
Gross Margin/M^3 of Water				2.1
Gross Margin/Man Day of Labor				196.2

* Excludig Harvesting Cost

Appendix-B6

WHEAT CROP IN JAMRAO CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2284.0	6.0	13704.0
By-Product	Rs/Ha	2284.0	1.0	2169.8
Total Output	Rs/Ha			**15873.8**
Production Cost				
Seed	Kg/Ha	135.0	8.5	1147.5
Fertilizer	Urea(Bags)	5.8	366.0	2122.8
	DAP (Bags)	1.6	586.0	937.6
	NP (Bags)	0.5	466.0	233.0
	AN (Bags)	0.2	258.0	38.7
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			2112.0
Family Labor	Man day*	21.0	77.0	1617.0
Casual Labor (Harvesting)	Rs/Ha			1118.0
Machinery Cost(Threshing)	Rs/Ha	2284.0	0.5	1142.0
Taxes	Rs/Ha			304.0
Irrigation	Canal(5 irrii)	1645.3	0.1	112.0
Total Cost				**10884.6**
Gross Margin Per Hectare				**4989.2**
Gross Margin/M^3 of Water				3.0
Gross Margin/Man Day of Labor				237.6

* Excludig Harvesting Cost

Appendix-B7

WHEAT CROP IN KHAIRPUR EAST CANAL (1996-97).

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2299.0	6.0	13794.0
By-Product	Rs/Ha	2299.0	0.9	2069.1
Total Output	Rs/Ha		.	**15863.1**
Production Cost				
Seed	Kg/Ha	135.0	8.0	1080.0
Fertilizer	Urea(Bags)	4.5	366.0	1647.0
	DAP (Bags)	2.0	586.0	1172.0
	NP (Bags)	0.1	466.0	46.6
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			1619.0
Family Labor	Man day*	20.0	77.0	1540.0
Casual Labor (Harvesting)	Rs/Ha			1193.0
Machinery Cost(Threshing)	Rs/Ha	2299.0	0.5	1149.5
Taxes	Rs/Ha			326.0
Irrigation	Canal(3 irrii)	1028.3	0.1	111.0
	Tubewel(5irrii	1542.5	0.6	926.0
Total Cost				**10810.1**
Gross Margin Per Hectare				**5053.0**
Gross Margin/M^3 of Water				2.0
Gross Margin/Man Day of Labor				252.7

* Excludig Harvesting Cost

Appendix-B8

WHEAT CROP IN KHAIRPUR WEST CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2022.0	6.0	12132.0
By-Product	Rs/Ha	2022.0	0.9	1819.8
Total Output	Rs/Ha			**13951.8**
Production Cost				
Seed	Kg/Ha	134.0	8.0	1072.0
Fertilizer	Urea(Bags)	4.0	366.0	1464.0
	DAP (Bags)	2.0	586.0	1172.0
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			1924.0
Family Labor	Man day*	18.0	77.0	1386.0
Casual Labor (Harvesting)	Rs/Ha			1193.0
Machinery Cost(Threshing)	Rs/Ha	2022.0	0.4	808.8
Taxes	Rs/Ha			345.0
Irrigation	Canal(3 irrii)	1028.3	0.1	114.0
	Tubewel(4irrii)	1234.0	0.8	988.0
Total Cost				**10466.8**
Gross Margin Per Hectare				**3485.0**
Gross Margin/M^3 of Water				1.5
Gross Margin/Man Day of Labor				193.6

* Excludig Harvesting Cost Cost

Appendix-B13

WHEAT CROP IN RICE CANAL.

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	1209.0	6.5	7858.5
By-Product	Rs/Ha	1209.0	0.8	967.2
Total Output	Rs/Ha			**8825.7**
Production Cost				
Seed	Kg/Ha	103.0	8.5	875.5
Fertilizer	Urea(Bags)	1.5	366.0	549.0
	DAP (Bags)	0.5	586.0	293.0
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			1178.0
Family Labor	Man day*	14.0	77.0	1078.0
Casual Labor (Harvesting)	Rs/Ha			904.0
		1209.0	0.5	604.5
Machinery Cost(Threshing)	Rs/Ha			
				314.0
Taxes	Rs/Ha			
Irrigation	Canal(1 irrii)	411.3	0.0	0.0
	Tubewel(2irrii)	617.0	0.8	494.0
Total Cost				**6290.0**
Gross Margin Per Hectare				**2535.7**
Gross Margin/M^3 of Water				2.5
Gross Margin/Man Day of Labor				181.1

* Excludig Harvesting Cost

Appendix-B14

WHEAT CROP IN ROHRI CANAL.

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2563.0	6.0	15378.0
By-Product	Rs/Ha	2563.0	0.9	2306.7
Total Output	Rs/Ha			**17684.7**
Production Cost				
Seed	Kg/Ha	132.0	8.0	1056.0
Fertilizer	Urea(Bags)	5.0	366.0	1830.0
	DAP (Bags)	1.8	586.0	1054.8
	NP (Bags)	0.2	466.0	93.2
	AN (Bags)	0.1	258.0	25.8
FYM		0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			1672.0
Family Labor	Man day*	21.0	77.0	1617.0
Casual Labor (Harvesting)	Rs/Ha			1208.0
		2563.0	0.5	1281.5
Machinery Cost(Threshing)	Rs/Ha			
				318.0
Taxes	Rs/Ha			
Irrigation	Canal(4 irrii)	1336.8	0.1	113.0
	Tubewel(2irrii)	617.0	0.9	584.0
Total Cost				**10853.3**
Gross Margin Per Hectare				**6831.4**
Gross Margin/M^3 of Water				3.5
Gross Margin/Man Day of Labor				325.3

* Excludig Harvesting Cost

COTTON CROP IN FULELI CANAL (1997).

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	1778.0	20.0	35560.0
By-Product				0.0
Total Output (Rupees/Ha)	Rs/Ha			**35560.0**
Production Cost				
Seed	Kg/Ha	10.7	46.8	500.2
Fertilizer (Bag)	Urea (Bags)	5.0	366.0	1830.0
	DAP (Bags)	1.6	586.0	937.6
	NP (Bags)	0.3	466.0	139.8
	AN (Bags)	0.0	258.0	0.0
FYM		0.7	159.0	104.9
Pesticide/Chemical Spray	Numbers	4.0	885.0	3540.0
Cost of Land Preperation	Rs/Ha			2766.0
Seed Bed Preperation	Rs/Ha			494.0
Family Labor	Man days*	32.0	77.0	2464.0
Casual Labor (Picking)	Rs/Ha	1778.0	1.5	2667.0
Sowing	Rs/Ha			463.0
Interculture(Weeding/Hoeing)	Rs/Ha			2284.0
Taxes				354.0
Irrigation	Canal(6)	1953.8	0.1	198.0
	Tubewel(4)	1234.0	0.7	913.0
Total Cost				**19655.6**
Gross Margin Per Hectare				**15904.4**
Gross Margin/M^3 of Water				5
Gross Margin/Man Day of Labour				497

* Excluding Picking Cost

COTTON CROP IN GHOTKI CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	1663.0	21.6	35920.8
By-Product				0.0
Total Output (Rupees/Ha)	Rs/Ha			**35920.8**
Production Cost				
Seed	Kg/Ha	21.0	27.0	567.0
Fertilizer (Bag)	Urea (Bags)	5.4	366.0	1976.4
	DAP (Bags)	1.8	586.0	1054.8
	NP (Bags)	0.2	466.0	93.2
	AN (Bags)	0.0	258.0	0.0
FYM		0.7	159.0	104.9
Pesticide/Chemical Spray	Numbers	10.0	150.0	1500.0
Cost of Land Preperation	Rs/Ha			2234.0
Seed Bed Preperation	Rs/Ha			0.0
Family Labor	Man days*	28.0	77.0	2156.0
Casual Labor (Picking)	Rs/Ha	1663.0	1.7	2827.1
Sowing	Rs/Ha			422.5
Interculture(Weeding/Hoeing)	Rs/Ha			1038.0
Taxes				580.0
Irrigation	Canal(4)	1336.8	0.1	197.0
	Tubewel(3)	925.5	0.8	755.0
Total Cost				**15505.9**
Gross Margin Per Hectare				20414.9
Gross Margin/M^3 of Water				9.0
Gross Margin/Man Day of Labour				**729.1**

* Excluding Picking

Appendix-C3

COTTON CROP IN JAMRAO CANAL.

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	1888.0	20.0	37760.0
By-Product				0.0
Total Output (Rupees/Ha)	Rs/Ha			**37760.0**
Production Cost				
Seed	Kg/Ha	13.0	36.5	474.5
Fertilizer (Bag)	Urea (Bags)	6.0	366.0	2196.0
	DAP (Bags)	1.6	586.0	937.6
	NP (Bags)	1.4	466.0	652.4
	AN (Bags)	0.8	258.0	206.4
FYM		0.7	159.0	104.9
Pesticide/Chemical Spray	Numbers	18.0	144.0	2592.0
Cost of Land Preperation	Rs/Ha			2788.0
Seed Bed Preperation	Rs/Ha			617.0
Family Labor	Man days*	35.0	77.0	2695.0
Casual Labor (Picking)	Rs/Ha	1888.0	1.8	3398.4
Sowing	Rs/Ha			522.8
Interculture(Weeding/Hoeing)	Rs/Ha			2274.0
Taxes				454.0
Irrigation	Canal(8)	2570.8	0.1	199.0
	Tubewel(4)	1234.0	0.7	913.0
Total Cost				**21025.0**
Gross Margin Per Hectare				16735.0
Gross Margin/M^3 of Water				4.4
Gross Margin/Man Day of Labour				**478.1**

* Excluding Picking Cost

Appendix-C4

COTTON CROP IN KHAIRPUR EAST.

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	1400.0	21.0	29400.0
By-Product				0.0
Total Output (Rupees/Ha)	Rs/Ha			**29400.0**
Production Cost				
Seed	Kg/Ha	19.8	24.0	475.2
Fertilizer (Bag)	Urea (Bags)	5.0	366.0	1830.0
	DAP (Bags)	1.8	586.0	1054.8
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		6.0	225.0	1350.0
Pesticide/Chemical Spray	Numbers	3.0	920.0	2760.0
Cost of Land Preperation	Rs/Ha			1909.0
Seed Bed Preperation	Rs/Ha			0.0
Family Labor	Man days*	29.0	77.0	2233.0
Casual Labor (Picking)	Rs/Ha	1400.0	1.7	2380.0
Sowing	Rs/Ha			397.0
Interculture(Weeding/Hoeing)	Rs/Ha			1220.0
Taxes				565.0
Irrigation	Canal(4)	1336.8	0.1	197.0
	Tubewel(10)	3085.0	0.6	1853.0
Total Cost				**18224.0**
Gross Margin Per Hectare				11176.0
Gross Margin/M^3 of Water				2.5
Gross Margin/Man Day of Labour				**385.4**

* Excluding Picking Cost

COTTON CROP IN KHAIRPUR WEST.

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	1051.0	20.0	21020.0
By-Product				0.0
Total Output (Rupees/Ha)	Rs/Ha			**21020.0**
Production Cost				
Seed	Kg/Ha	22.0	27.0	594.0
Fertilizer (Bag)	Urea (Bags)	5.0	366.0	1830.0
	DAP (Bags)	2.0	586.0	1172.0
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		5.0	200.0	1000.0
Pesticide/Chemical Spray	Numbers	3.0	977.0	2931.0
Cost of Land Preperation	Rs/Ha			2280.0
Seed Bed Preperation	Rs/Ha			0.0
Family Labor	Man days*	26.0	77.0	2002.0
Casual Labor (Picking)	Rs/Ha	1051.0	2.0	2102.0
Sowing	Rs/Ha			508.0
Interculture(Weeding/Hoeing)	Rs/Ha			1127.0
Taxes				380.0
Irrigation	Canal(4)	1336.8	0.1	195.0
	Tubewel(5)	1542.5	0.9	1399.0
Total Cost				**17520.0**
Gross Margin Per Hectare				3500.0
Gross Margin/M^3 of Water				1.2
Gross Margin/Man Day of Labour				**134.6**

* Excluding Picking Cost

COTTON CROP IN LINED CANAL.

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	1551.0	19.0	29469.0
By-Product				0.0
Total Output (Rupees/Ha)	Rs/Ha			**29469.0**
Production Cost				
Seed	Kg/Ha	7.0	55.0	385.0
Fertilizer (Bag)	Urea (Bags)	5.0	366.0	1830.0
	DAP (Bags)	1.4	586.0	820.4
	NP (Bags)	1.4	466.0	652.4
	AN (Bags)	0.0	258.0	0.0
FYM		0.7	159.0	104.9
Pesticide/Chemical Spray	Numbers	3.0	789.0	2367.0
Cost of Land Preperation	Rs/Ha			2889.0
Seed Bed Preperation	Rs/Ha			0.0
Family Labor	Man days*	29.0	77.0	2233.0
Casual Labor (Picking)	Rs/Ha	1551.0	1.4	2171.4
Sowing	Rs/Ha			631.0
Interculture(Weeding/Hoeing)	Rs/Ha			2413.0
Taxes				659.0
Irrigation	Canal(7)	2262.3	0.1	198.0
	Tubewel(4)	1234.0	0.7	913.0
Total Cost				**18267.1**
Gross Margin Per Hectare				11201.9
Gross Margin/M^3 of Water				3.2
Gross Margin/Man Day of Labour				**386.3**

* Excluding Picking Cost

Appendix-C7

COTTON CROP IN NARA CANAL.

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2051.0	19.8	40609.8
By-Product				0.0
Total Output (Rupees/Ha)	Rs/Ha			**40609.8**
Production Cost				
Seed	Kg/Ha	10.0	43.0	430.0
Fertilizer (Bag)	Urea (Bags)	5.9	366.0	2159.4
	DAP (Bags)	1.5	586.0	879.0
	NP (Bags)	1.8	466.0	838.8
	AN (Bags)	1.4	258.0	361.2
FYM		0.7	159.0	104.9
Pesticide/Chemical Spray	Numbers	0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			2827.0
Seed Bed Preperation	Rs/Ha			0.0
Family Labor	Man days*	32.0	77.0	2464.0
Casual Labor (Picking)	Rs/Ha	2051.0	1.7	3486.7
Sowing	Rs/Ha			474.0
Interculture(Weeding/Hoeing)	Rs/Ha			3004.0
Taxes				572.0
Irrigation	Canal(8)	2570.8	0.1	196.0
	Tubewel(4)	1234.0	0.7	913.0
Total Cost				**18710.0**
Gross Margin Per Hectare				21899.8
Gross Margin/M^3 of Water				5.8
Gross Margin/Man Day of Labour				**684.4**

* Excluding Picking Cost

Appendix-C8

COTTON CROP IN ROHRI CANAL.

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	1689.0	20.8	35131.2
By-Product				0.0
Total Output (Rupees/Ha)	Rs/Ha			**35131.2**
Production Cost				
Seed	Kg/Ha	18.5	29.0	536.5
Fertilizer (Bag)	Urea (Bags)	5.0	366.0	1830.0
	DAP (Bags)	1.8	586.0	1054.8
	NP (Bags)	0.4	466.0	186.4
	AN (Bags)	0.2	258.0	51.6
FYM		0.7	159.0	104.9
Pesticide/Chemical Spray	Numbers	0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			2105.0
Seed Bed Preperation	Rs/Ha			531.0
Family Labor	Man days*	26.0	77.0	2002.0
Casual Labor (Picking)	Rs/Ha	1689.0	1.7	2871.3
Sowing	Rs/Ha			410.0
Interculture(Weeding/Hoeing)	Rs/Ha			1754.0
Taxes				514.0
Irrigation	Canal(5)	1645.3	0.1	198.0
	Tubewel(3)	925.5	0.6	549.0
Total Cost				**14698.5**
Gross Margin Per Hectare				20432.7
Gross Margin/M^3 of Water				7.9
Gross Margin/Man Day of Labour				**785.9**

* Excluding Picking Cost

SUGARCANE CROP IN DADU CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	61997.0	0.9	55797.3
By-Product	Rs/Ha			
Total Output				**55797.3**
Production Cost				
Seed	Kg/Ha	7008.0	1.0	7008.0
Fertilizer	Urea (Bags)	8.0	366.0	2928.0
	DAP (Bags)	2.8	586.0	1640.8
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		12.0	100.0	1200.0
Pesticide/Chemical Spray	Numbers	0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			2584.0
Seed Bed Preperation	Rs/Ha			0.0
Family Labor	Man days*	44.0	77.0	3388.0
Casual Labor (Harvesting)	Rs/Ha	61997.0	0.1	6199.7
Sowing	Rs/Ha			1096.0
Interculture (Weeding/Hoeing)	Rs/Ha			1534.0
Taxes	Rs/Ha			898.0
Irrigation	Canal(16 irri.)	5038.8	0.1	390.0
Total Cost				**28866.5**
Gross Margin Per Hectare				**26930.8**
Gross Margin /M3 of Water				5.3
Gross Margin /Man Day of Labor				612.1

* Excluding Cost of Harvesting

SUGARCANE CROP IN FULELI CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	62208.0	1.0	62208.0
By-Product	Rs/Ha			
Total Output				**62208.0**
Production Cost				
Seed	Kg/Ha	7870.0	1.0	7870.0
Fertilizer	Urea (Bags)	8.6	366.0	3147.6
	DAP (Bags)	3.0	586.0	1758.0
	NP (Bags)	0.1	466.0	46.6
	AN (Bags)	0.2	258.0	51.6
FYM		9.0	150.0	1350.0
Pesticide/Chemical Spray	Numbers	2.0	1056.0	2112.0
Cost of Land Preperation	Rs/Ha			2987.0
Seed Bed Preperation	Rs/Ha			296.0
Family Labor	Man days*	51.0	77.0	3927.0
Casual Labor (Harvesting)	Rs/Ha	62208.0	0.1	6220.8
Sowing	Rs/Ha			772.0
Interculture (Weeding/Hoeing)	Rs/Ha			2143.0
Taxes	Rs/Ha			783.0
Irrigation	Canal(18 irri.	5655.8	0.1	391.0
Total Cost				**33855.6**
Gross Margin Per Hectare				**28352.4**
Gross Margin /M3 of Water				5.0
Gross Margin /Man Day of Labor				555.9

* Excluding Cost of Harvesting

Appendix-D3

SUGARCANE CROP IN GHOTKI CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	77187	0.9	69468.3
By-Product	Rs/Ha			172.0
Total Output				**69640.3**
Production Cost				
Seed	Kg/Ha	6254.0	0.9	5628.6
Fertilizer	Urea (Bags)	6.0	366.0	2196.0
	DAP (Bags)	2.0	586.0	1172.0
	NP (Bags)	0.1	466.0	46.6
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Pesticide/Chemical Spray	Numbers	1.0	1235.0	1235.0
Cost of Land Preperation	Rs/Ha			2613.0
Seed Bed Preperation	Rs/Ha			0.0
Family Labor	Man days*	45.0	77.0	3465.0
Casual Labor (Harvesting)	Rs/Ha	77187.0	0.1	7718.7
Sowing	Rs/Ha			839.0
Interculture (Weeding/Hoeing)	Rs/Ha			607.0
Taxes	Rs/Ha			939.0
Irrigation	Canal(11 irri.)	3496.3	0.1	368.0
	Tubewel(6 irri	1851.0	0.7	1305.0
Total Cost				**28132.9**
Gross Margin Per Hectare				**41507.4**
Gross Margin /M3 of Water				7.8
Gross Margin /Man Day of Labor				922.4

* Excluding Cost of Harvesting

Appendix-D4

SUGARCANE CROP IN JAMRAO CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product		63171.0	0.9	56853.9
By-Product	Rs/Ha			
Total Output				**56853.9**
Production Cost				
Seed	Kg/Ha	8168.0	1.0	8168.0
Fertilizer	Urea (Bags)	9.0	366.0	3294.0
	DAP (Bags)	3.0	586.0	1758.0
	NP (Bags)	1.6	466.0	745.6
	AN (Bags)	1.0	258.0	258.0
FYM		8.0	178.0	1424.0
Pesticide/Chemical Spray	Numbers	1.0	1247.0	1247.0
Cost of Land Preperation	Rs/Ha			2858.0
Seed Bed Preperation	Rs/Ha			78.0
Family Labor	Man days*	54.0	77.0	4158.0
Casual Labor (Harvesting)	Rs/Ha	63171.0	0.1	6317.1
Sowing	Rs/Ha			705.0
Interculture (Weeding/Hoeing)	Rs/Ha			2886.0
Taxes	Rs/Ha			899.0
Irrigation	Canal(18 irri.	5655.8	0.1	390.0
Total Cost				**35185.7**
Gross Margin Per Hectare				**21668.2**
Gross Margin /M3 of Water				3.8
Gross Margin /Man Day of Labor				401.3

SUGARCANE CROP IN KHAIR PUR EAST CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	65962.0	0.8	52769.6
By-Product	Rs/Ha			
Total Output				**52769.6**
Production Cost				
Seed	Kg/Ha	5252.0	1.0	5252.0
Fertilizer	Urea (Bags)	8.0	366.0	2928.0
	DAP (Bags)	3.0	586.0	1758.0
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		9.0	200.0	1800.0
Pesticide/Chemical Spray	Numbers	0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			2383.0
Seed Bed Preperation	Rs/Ha			140.0
Family Labor	Man days*	41.0	77.0	3157.0
Casual Labor (Harvesting)	Rs/Ha	65962.0	0.1	6596.2
Sowing	Rs/Ha			650.0
Interculture (Weeding/Hoeing)	Rs/Ha			665.0
Taxes	Rs/Ha			870.0
Irrigation	Canal(11 irri.)	3496.3	0.1	371.0
Total Cost				**26570.2**
Gross Margin Per Hectare				**26199.4**
Gross Margin /M3 of Water				7.5
Gross Margin /Man Day of Labor				639.0

* Excluding Cost of Harvesting

SUGARCANE CROP IN KHAIRPUR WEST CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	56261.0	0.9	50634.9
By-Product	Rs/Ha			0.0
Total Output				**50634.9**
Production Cost				
Seed	Kg/Ha	4954.0	0.8	3963.2
Fertilizer	Urea (Bags)	5.7	366.0	2086.2
	DAP (Bags)	3.0	586.0	1758.0
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.1	258.0	25.8
FYM		12.0	150.0	1800.0
Pesticide/Chemical Spray	Numbers	1.0	1037.0	1037.0
Cost of Land Preperation	Rs/Ha			2376.0
Seed Bed Preperation	Rs/Ha			0.0
Family Labor	Man days*	36.0	77.0	2772.0
Casual Labor (Harvesting)	Rs/Ha	56261.0	0.1	5626.1
Sowing	Rs/Ha			408.0
Interculture (Weeding/Hoeing)	Rs/Ha			377.0
Taxes	Rs/Ha			936.0
Irrigation	Canal(11 irri.	3496.3	0.1	394.0
Total Cost				**23559.3**
Gross Margin Per Hectare				**27075.6**
Gross Margin /M3 of Water				7.7
Gross Margin /Man Day of Labor				752.1

* Excluding Cost of Harvesting

Appendix-D7

SUGARCANE CROP IN LINED CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	62686.0	1.0	62686.0
By-Product	Rs/Ha			
Total Output				**62686.0**
Production Cost				
Seed	Kg/Ha	8095.0	1.0	8095.0
Fertilizer	Urea (Bags)	9.0	366.0	3294.0
	DAP (Bags)	3.8	586.0	2226.8
	NP (Bags)	0.6	466.0	279.6
	AN (Bags)	0.0	258.0	0.0
FYM		6.0	175.0	1050.0
Pesticide/Chemical Spray	Numbers	1.0	1207.0	1207.0
Cost of Land Preperation	Rs/Ha			3499.0
Seed Bed Preperation	Rs/Ha			0.0
Family Labor	Man days*	55.0	77.0	4235.0
Casual Labor (Harvesting)	Rs/Ha	62686.0	0.1	6268.6
Sowing	Rs/Ha			800.0
Interculture (Weeding/Hoeing)	Rs/Ha			2771.0
Taxes	Rs/Ha			989.0
Irrigation	Canal(16 irri.)	5038.8	0.1	383.0
	Tubewel(7 irri	2159.5	0.7	1423.0
Total Cost				**36521.0**
Gross Margin Per Hectare				**26165.0**
Gross Margin /M3 of Water				3.6
Gross Margin /Man Day of Labor				475.7

* Excluding Cost of Harvesting

Appendix-D8

SUGARCANE CROP IN NARA CANAL.

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	69160.0	1.0	69160.0
By-Product	Rs/Ha			
Total Output				**69160.0**
Production Cost				
Seed	Kg/Ha	8477.0	1.0	8477.0
Fertilizer	Urea (Bags)	9.0	366.0	3294.0
	DAP (Bags)	3.0	586.0	1758.0
	NP (Bags)	1.6	466.0	745.6
	AN (Bags)	0.8	258.0	206.4
FYM		0.0	0.0	0.0
Pesticide/Chemical Spray	Numbers	0.0	0.0	0.0
Cost of Land Preperation	Rs/Ha			3310.0
Seed Bed Preperation	Rs/Ha			0.0
Family Labor	Man days*	51.0	77.0	3927.0
Casual Labor (Harvesting)	Rs/Ha	69160.0	0.1	6916.0
Sowing	Rs/Ha			975.0
Interculture (Weeding/Hoeing)	Rs/Ha			2669.0
Taxes	Rs/Ha			898.0
Irrigation	Canal(16 irri.	5038.8	0.1	353.0
Total Cost				**33529.0**
Gross Margin Per Hectare				**35631.0**
Gross Margin /M3 of Water				7.1
Gross Margin /Man Day of Labor				698.6

* Excluding Cost of Harvesting

Appendix-D9

SUGARCANE CROP IN NORTH WEST CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	50223.0	1.0	50223.0
By-Product	Rs/Ha			
Total Output				**50223.0**
Production Cost				
Seed	Kg/Ha	7739.0	1.0	7739.0
Fertilizer	Urea (Bags)	5.0	366.0	1830.0
	DAP (Bags)	2.5	586.0	1465.0
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		0.0	0.0	0.0
Pesticide/Chemical Spray	Numbers	1.0	1482.0	1482.0
Cost of Land Preperation	Rs/Ha			2478.0
Seed Bed Preperation	Rs/Ha			0.0
Family Labor	Man days*	39.0	77.0	3003.0
Casual Labor (Harvesting)	Rs/Ha	50223.0	0.1	5022.3
Sowing	Rs/Ha			547.0
Interculture (Weeding/Hoeing)	Rs/Ha			1062.0
Taxes	Rs/Ha			984.0
Irrigation	Canal(10 irri.)	3187.8	0.1	394.0
Total Cost				**26006.3**
Gross Margin Per Hectare				**24216.7**
Gross Margin /M3 of Water				7.6
Gross Margin /Man Day of Labor				620.9

* Excluding Cost of Harvesting

Appendix-D10

SUGARCANE CROP IN PINYARI CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	68419.0	0.9	61577.1
By-Product	Rs/Ha			
Total Output				**61577.1**
Production Cost				
Seed	Kg/Ha	9101.0	0.9	8190.9
Fertilizer	Urea (Bags)	8.4	366.0	3074.4
	DAP (Bags)	4.0	586.0	2344.0
	NP (Bags)	0.0	466.0	0.0
	AN (Bags)	0.0	258.0	0.0
FYM		9.0	164.0	1476.0
Pesticide/Chemical Spray	Numbers	2.0	988.0	1976.0
Cost of Land Preperation	Rs/Ha			2842.0
Seed Bed Preperation	Rs/Ha			351.0
Family Labor	Man days*	53.0	77.0	4081.0
Casual Labor (Harvesting)	Rs/Ha	68419.0	0.1	6841.9
Sowing	Rs/Ha			773.0
Interculture (Weeding/Hoeing)	Rs/Ha			2120.0
Taxes	Rs/Ha			717.0
Irrigation	Canal(19 irri.	5964.3	0.1	390.0
Total Cost				**35177.2**
Gross Margin Per Hectare				**26399.9**
Gross Margin /M3 of Water				4.4
Gross Margin /Man Day of Labor				498.1

* Excluding Cost of Harvesting

Appendix-D11

SUGARCANE CROP IN ROHRI CANAL (1996-97)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	71529.0	0.9	64376.1
By-Product	Rs/Ha			
Total Output				**64376.1**
Production Cost				
Seed	Kg/Ha	6516.0	0.9	5864.4
Fertilizer	Urea (Bags)	8.0	366.0	2928.0
	DAP (Bags)	3.5	586.0	2051.0
	NP (Bags)	0.7	466.0	326.2
	AN (Bags)	0.3	258.0	77.4
FYM		9.0	166.0	1494.0
Pesticide/Chemical Spray	Numbers	1.0	1077.0	1077.0
Cost of Land Preperation	Rs/Ha			2472.0
Seed Bed Preperation	Rs/Ha			124.0
Family Labor	Man days*	50.0	77.0	3850.0
Casual Labor (Harvesting)	Rs/Ha	71529.0	0.1	7152.9
Sowing	Rs/Ha			600.0
Interculture (Weeding/Hoeing)	Rs/Ha			1875.0
Taxes	Rs/Ha			840.0
Irrigation	Canal(15 irri.)	4730.3	0.1	383.0
	Tubewel(8 irri	2468.0	0.6	1423.0
Total Cost				32537.9
Gross Margin Per Hectare				**31838.2**
Gross Margin /M3 of Water				4.4
Gross Margin /Man Day of Labor				636.8

* Excluding Cost of Harvesting

Appendix-E1

RICE CROP IN BEGARI CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	3506.0	5.0	17530.0
By-Product	Rs/Ha			513.0
Total	Rs/Ha			**18043.0**
Production Cost				
Seed	Kg/Ha	101.0	5.5	555.5
Fertilizer	Urea (Bags)	2.7	366.0	988.2
	DAP (Bags)	1.8	586.0	1054.8
	Zinc (Bags)	0.2	88.0	15.0
FYM		0.0	150.0	0.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			1355.0
Puddling	Rs/Ha			119.0
Family Labor	Man days*	20.0	77.0	1540.0
Casual Labor (Transplanting)	Rs/Ha			900.0
Casual Labor (Harvesting)	Rs/Ha			499.0
Machinery Cost(Threshing)	Rs/Ha	3506.0	0.1	350.6
Interculture(Weeding)	Rs/Ha			
				349.0
Taxes	Rs/Ha			
Irrigation	Canal 20irri.	6272.8	0.0	190.0
	Tubewel(7 irri.)	2159.5	0.9	1893.0
Total Cost				10164.1
Gross Margin Per Hectare				**7878.9**
Gross Margin /$M^3$of Water				0.9
Gross Margin /Man Day of Labor				393.9

* Excluding Transplating & Harvesting Cost

Appendix-E2

RICE CROP IN DADU CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	3944.0	5.0	19720.0
By-Product	Rs/Ha			368.0
Total	Rs/Ha			**20088.0**
Production Cost				
Seed	Kg/Ha	97.0	5.5	533.5
Fertilizer	Urea (Bags)	3.5	366.0	1281.0
	DAP (Bags)	1.6	586.0	937.6
	Zinc (Bags)	0.9	89.0	80.1
FYM		0.4	150.0	60.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			1817.0
Puddling	Rs/Ha			84.0
Family Labor	Man days*	21.0	77.0	1617.0
Casual Labor (Transplanting)	Rs/Ha			1013.0
Casual Labor (Harvesting)	Rs/Ha			499.0
Machinery Cost(Threshing)	Rs/Ha	3944.0	0.1	394.4
Interculture(Weeding)	Rs/Ha			
				362.0
Taxes	Rs/Ha			
Irrigation	Canal 21irri.	6581.3	0.0	190.0
Total Cost				**9223.6**
Gross Margin Per Hectare				**10864.4**
Gross Margin /$M^3$of Water				1.7
Gross Margin /Man Day of Labor				**517.4**

* Excluding Transplating & Harvesting Cost

Appendix-E3

RICE CROP IN DESERT CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	3764.0	5.0	18820.0
By-Product	Rs/Ha			437.0
Total	Rs/Ha			**19257.0**
Production Cost				
Seed	Kg/Ha	112.0	5.0	560.0
Fertilizer	Urea (Bags)	2.3	366.0	841.8
	DAP (Bags)	2.0	586.0	1172.0
	Zinc (Bags)	0.0	88.0	0.0
FYM		0.0	150.0	0.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			1125.0
Puddling	Rs/Ha			137.0
Family Labor	Man days*	17.0	77.0	1309.0
Casual Labor (Transplanting)	Rs/Ha			971.0
Casual Labor (Harvesting)	Rs/Ha			504.0
Machinery Cost(Threshing)	Rs/Ha	3764.0	0.1	376.4
Interculture(Weeding)	Rs/Ha			
				361.0
Taxes	Rs/Ha			
Irrigation	Canal 17irri.	5347.3	0.0	190.0
Total Cost				7902.2
Gross Margin Per Hectare				**11354.8**
Gross Margin /$M^3$of Water				2.1
Gross Margin /Man Day of Labor				667.9

* Excluding Transplating & Harvesting Cost

Appendix-E4

RICE CROP IN FULELI CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	3284.0	4.8	15763.2
By-Product	Rs/Ha			540.0
Total	Rs/Ha			**16303.2**
Production Cost				
Seed	Kg/Ha	70.0	5.0	350.0
Fertilizer	Urea (Bags)	5.0	366.0	1830.0
	DAP (Bags)	1.0	586.0	586.0
	Zinc (Bags)	0.0	88.0	0.0
FYM		0.6	150.0	90.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			2214.0
Puddling	Rs/Ha			0.0
Family Labor	Man days*	21.0	77.0	1617.0
Casual Labor (Transplanting)	Rs/Ha			625.0
Casual Labor (Harvesting)	Rs/Ha			497.0
Machinery Cost(Threshing)	Rs/Ha	3284.0	0.1	328.4
Interculture(Weeding)	Rs/Ha			
				308.0
Taxes	Rs/Ha			
Irrigation	Canal 17irri.	5347.3	0.0	186.0
Total Cost				**8986.4**
Gross Margin Per Hectare				**7316.8**
Gross Margin /$M^3$of Water				1.4
Gross Margin /Man Day of Labor				**348.4**

* Excluding Transplating & Harvesting Cost

RICE CROP IN GHOTKI CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2688.0	5.0	13440.0
By-Product	Rs/Ha			203.0
Total	Rs/Ha			**13643.0**
Production Cost				
Seed	Kg/Ha	51.0	6.0	306.0
Fertilizer	Urea (Bags)	3.5	366.0	1281.0
	DAP (Bags)	1.0	586.0	586.0
	Zinc (Bags)	0.0	88.0	0.0
FYM		0.0	150.0	0.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			1526.0
Puddling	Rs/Ha			0.0
Family Labor	Man days*	24.0	77.0	1848.0
Casual Labor (Transplanting)	Rs/Ha			858.0
Casual Labor (Harvesting)	Rs/Ha			497.0
Machinery Cost(Threshing)	Rs/Ha	2688.0	0.1	268.8
Interculture(Weeding)	Rs/Ha			
				349.0
Taxes	Rs/Ha			
Irrigation	Canal 21irri.	6581.3	0.0	180.0
	Tubewel(2 irri.)	617.0	1.6	988.0
Total Cost				**9042.8**
Gross Margin Per Hectare				**4600.2**
Gross Margin /M³of Water				0.6
Gross Margin /Man Day of Labor				191.7

* Excluding Transplating & Harvesting Cost

RICE CROP IN JAMRAO CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2823.0	4.7	13268.1
By-Product	Rs/Ha			511.0
Total	Rs/Ha			**13779.1**
Production Cost				
Seed	Kg/Ha	48.0	5.5	264.0
Fertilizer	Urea (Bags)	5.0	366.0	1830.0
	DAP (Bags)	0.8	586.0	468.8
	NP (Bags)	0.3	466.0	139.8
FYM		0.0	150.0	0.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			1804.0
Puddling	Rs/Ha			70.0
Family Labor	Man days*	22.0	77.0	1694.0
Casual Labor (Transplanting)	Rs/Ha			794.0
Casual Labor (Harvesting)	Rs/Ha			504.0
Machinery Cost(Threshing)	Rs/Ha	2823.0	0.1	282.3
Interculture(Weeding)	Rs/Ha			
				347.0
Taxes	Rs/Ha			
Irrigation	Canal 20irri.	6272.8	0.0	191.0
Total Cost				**8743.9**
Gross Margin Per Hectare				**5035.2**
Gross Margin /M³of Water				0.8
Gross Margin /Man Day of Labor				228.9

* Excluding Transplating & Harvesting Cost

Appendix-E7

RICE CROP IN KHAIRPUR EAST CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2201.0	5.0	11005.0
By-Product	Rs/Ha			617.0
Total	Rs/Ha			**11622.0**
Production Cost				
Seed	Kg/Ha	67.0	5.7	381.9
Fertilizer	Urea (Bags)	2.7	366.0	988.2
	DAP (Bags)	2.0	586.0	1172.0
	NP (Bags)	0.2	466.0	79.2
FYM		0.0	150.0	0.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			1575.0
Puddling	Rs/Ha			0.0
Family Labor	Man days*	21.0	77.0	1617.0
Casual Labor (Transplanting)	Rs/Ha			705.0
Casual Labor (Harvesting)	Rs/Ha			502.0
Machinery Cost(Threshing)	Rs/Ha	2201.0	0.1	220.1
Interculture(Weeding)	Rs/Ha			
				342.0
Taxes	Rs/Ha			
Irrigation	Canal 17irri	5347.3	0.0	194.0
Total Cost				**8131.4**
Gross Margin Per Hectare				**3490.6**
Gross Margin /M³of Water				0.7
Gross Margin /Man Day of Labor				166.2

* Excluding Transplating & Harvesting Cost

Appendix-E8

RICE CROP IN KHAIRPUR WEST CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	3188.0	4.7	14983.6
By-Product	Rs/Ha			427.0
Total	Rs/Ha			**15410.6**
Production Cost				
Seed	Kg/Ha	54.0	5.7	307.8
Fertilizer	Urea (Bags)	4.0	366.0	1464.0
	DAP (Bags)	1.6	586.0	937.6
	Zinc (Bags)	0.5	88.0	44.0
FYM		0.0	150.0	0.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			1824.0
Puddling	Rs/Ha			89.0
Family Labor	Man days*	20.0	77.0	1540.0
Casual Labor (Transplanting)	Rs/Ha			836.0
Casual Labor (Harvesting)	Rs/Ha			508.0
Machinery Cost(Threshing)	Rs/Ha	3188.0	0.1	318.8
Interculture(Weeding)	Rs/Ha			
				357.0
Taxes	Rs/Ha			
Irrigation	Canal 18irri	5655.8	0.0	187.0
Total Cost				**8768.2**
Gross Margin Per Hectare				**6642.4**
Gross Margin /M³of Water				1.2
Gross Margin /Man Day of Labor				332.1

* Excluding Transplating & Harvesting Cost

Appendix-E9

RICE CROP IN LINED CHANNEL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	3058.0	4.7	14372.6
By-Product	Rs/Ha			653.0
Total	Rs/Ha			**15025.6**
Production Cost				
Seed	Kg/Ha	88.0	5.5	484.0
Fertilizer	Urea (Bags)	5.0	366.0	1830.0
	DAP (Bags)	0.4	586.0	234.4
FYM		0.6	150.0	90.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			1917.0
Puddling	Rs/Ha			121.0
Family Labor	Man days*	22.0	77.0	1694.0
Casual Labor (Transplanting)	Rs/Ha			792.0
Casual Labor (Harvesting)	Rs/Ha			507.0
Machinery Cost(Threshing)	Rs/Ha	3058.0	0.1	305.8
Interculture(Weeding)	Rs/Ha			
				330.0
Taxes	Rs/Ha			
Irrigation	Canal 21irri.	6581.3	0.0	190.0
Total Cost				**8859.2**
Gross Margin Per Hectare				**6166.4**
Gross Margin /M^{3}of Water				0.9
Gross Margin /Man Day of Labor				280.3

* Excluding Transplating & Harvesting Cost

Appendix-E10

RICE CROP IN NARA CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	3631.0	4.7	17065.7
By Product	Rs/Ha			123.5
Total	Rs/Ha			**17189.2**
Production Cost				
Seed	Kg/Ha	40.0	5.5	220.0
Fertilizer	Urea (Bags)	5.8	366.0	2122.8
	DAP (Bags)	0.8	586.0	439.5
	NP (Bags)	1.0	466.0	466.0
FYM		0.0	150.0	0.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			1809.0
Puddling	Rs/Ha			154.0
Family Labor	Man days*	23.0	77.0	1771.0
Casual Labor (Transplanting)	Rs/Ha			617.0
Casual Labor (Harvesting)	Rs/Ha			506.0
Machinery Cost(Threshing)	Rs/Ha	3631.0	0.1	363.1
Interculture(Weeding)	Rs/Ha			
				306.0
Taxes	Rs/Ha			
Irrigation	Canal 13irri.	4113.3	0.0	167.0
Total Cost				**9296.4**
Gross Margin Per Hectare				**7892.8**
Gross Margin /M^{3}of Water				1.9
Gross Margin /Man Day of Labor				343.2

* Excluding Transplating & Harvesting Cost

Appendix-E11

RICE CROP IN NORTH WEST CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	3617.0	5.0	18085.0
By-Product	Rs/Ha			596.0
Total	Rs/Ha			18681.0
Production Cost				
Seed	Kg/Ha	98.0	5.5	539.0
Fertilizer	Urea (Bags)	2.6	366.0	951.6
	DAP (Bags)	1.8	586.0	1054.8
	Zinc (Bags)	0.9	88.0	79.2
FYM		0.9	150.0	135.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			1404.0
Puddling	Rs/Ha			180.0
Family Labor	Man days*	24.0	77.0	1848.0
Casual Labor (Transplanting)	Rs/Ha			1002.0
Casual Labor (Harvesting)	Rs/Ha			505.0
Machinery Cost(Threshing)	Rs/Ha	3617.0	0.1	361.7
Interculture(Weeding)	Rs/Ha			
				361.0
Taxes	Rs/Ha			
Irrigation	Canal 20irri.	6272.8	0.0	189.0
	Tubewel(5 irri.)	1542.5	0.8	1235.0
Total Cost				10198.3
Gross Margin Per Hectare				8482.7
Gross Margin /M^{3}of Water				1.1
Gross Margin /Man Day of Labor				353.4

* Excluding Transplating & Harvesting Cost

Appendix-E12

RICE CROP IN PINYARI CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	2495.0	5.0	12475.0
By-Product	Rs/Ha			655.0
Total	Rs/Ha			13130.0
Production Cost				
Seed	Kg/Ha	88.0	5.5	484.0
Fertilizer	Urea (Bags)	5.0	366.0	1830.0
	DAP (Bags)	0.7	586.0	410.2
FYM		0.9	150.0	135.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			2230.0
Puddling	Rs/Ha			0.0
Family Labor	Man days*	21.0	77.0	1617.0
Casual Labor (Transplanting)	Rs/Ha			701.0
Casual Labor (Harvesting)	Rs/Ha			494.0
Machinery Cost(Threshing)	Rs/Ha	2495.0	0.1	249.5
Interculture(Weeding)	Rs/Ha			
				294.0
Taxes	Rs/Ha			
Irrigation	Canal 16irri.	5038.8	0.0	189.0
Total Cost				**8988.7**
Gross Margin Per Hectare				**4141.3**
Gross Margin /M^{3}of Water				0.8
Gross Margin /Man Day of Labor				197.2

* Excluding Transplating & Harvesting Cost

Appendix-13

RICE CROP IN RICE CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	4399.0	5.0	21995.0
By-Product	Rs/Ha			569.0
Total	Rs/Ha			22564.0
Production Cost				
Seed	Kg/Ha	93.0	5.0	465.0
Fertilizer	Urea (Bags)	2.8	366.0	1024.8
	DAP (Bags)	2.0	586.0	1172.0
	Zinc (Bags)	1.0	88.0	88.0
FYM		0.5	150.0	75.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			1678.0
Puddling	Rs/Ha			186.0
Family Labor	Man days*	23.0	77.0	1771.0
Casual Labor (Transplanting)	Rs/Ha			994.0
Casual Labor (Harvesting)	Rs/Ha			501.0
Machinery Cost(Threshing)	Rs/Ha	4399.0	0.1	439.9
Interculture(Weeding)	Rs/Ha			
				349.0
Taxes	Rs/Ha			
Irrigation	Canal 20irri.	6272.8	0.0	188.0
Total Cost				9286.7
Gross Margin Per Hectare				13277.3
Gross Margin /M^{3}of Water				2.1
Gross Margin /Man Day of Labor				577.3

* Excluding Transplating & Harvesting Cost

Appendix-E14

RICE CROP IN ROHRI CANAL (1997)

	Units	Quantity	Unit Price (financial)	Rupees
Product	Kg/Ha	3498.0	5.0	17490.0
By-Product	Rs/Ha			533.0
Total	Rs/Ha			18023.0
Production Cost				
Seed	Kg/Ha	42.0	5.7	239.4
Fertilizer	Urea (Bags)	4.5	366.0	1647.0
	DAP (Bags)	1.5	586.0	879.0
FYM		0.0	150.0	0.0
Pesticide /Chemical Spray	Numbers	1.0	355.0	355.0
Cost of Land Preperation	Rs/Ha			1668.0
Puddling	Rs/Ha			0.0
Family Labor	Man days*	22.0	77.0	1694.0
Casual Labor (Transplanting)	Rs/Ha			806.0
Casual Labor (Harvesting)	Rs/Ha			505.0
Machinery Cost(Threshing)	Rs/Ha	3498.0	0.1	349.8
Interculture(Weeding)	Rs/Ha			
				304.0
Taxes	Rs/Ha			
Irrigation	Canal 16irri.	5038.8	0.0	190.0
	Tubewel(6 irri.	1851.0	1.0	1852.0
Total Cost				10489.2
Gross Margin Per Hectare				7533.8
Gross Margin /M^{3}of Water				1.1
Gross Margin /Man Day of Labor				342.4

* Excluding Transplating & Harvesting Cost

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	Volume II: Research Approach and Interpretation	Carlos Garces-R Ms. Zaigham Habib Pierre Strosser Tissa Bandaragoda Rana M. Afaq Saeed ur Rehman Abdul Hakim Khan	June 1994
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